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THE STUDY OF SOCIOLOGY.

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IV.—Difficulties of the Social Science.

FROM the intrinsic natures of its facts, from our own natures as observers of its facts, and from the peculiar relation in which we stand toward the facts to be observed, there arise impediments in the way of Sociology greater than those standing in the way of any other science.

The phenomena to be generalized are not of a directly-perceptible kind—cannot be noted by telescope and clock, like those of Astronomy; cannot be measured by dynamometer and thermometer, like those of Physics; cannot be elucidated by scales and test-papers, like those of Chemistry; are not to be got at by scalpel and microscope, like the less-obvious biological phenomena; nor are to be recognized by introspection, like the phenomena Psychology deals with. They have severally to be established by the putting together of many details, no one of which is simple, and which are dispersed both in Space and Time, in ways that make them difficult of access. Hence the reason that some of its cardinal truths, such as the division of labor, remain long unrecognized. That in advanced societies men follow different occupations, was indeed a generalization easy to make; but that this form of social arrangement had neither been specially created, nor enacted by a king, but had grown up without forethought of any one, was a conclusion that could be reached only after many transactions of many kinds between men had been noted, remembered, and accounted for, and only after comparisons had been made between those transactions and these taking place between men in simpler societies, and in earlier times. And when it is remembered that the data from which only there can be drawn the inference that labor be-

comes specialized, are far more accessible than the data for most other sociological inferences, it will be seen how greatly the advance of Sociology is hindered by the nature of its subject-matter.

The characters of men as observers, add to this first difficulty a second that is perhaps equally great. Necessarily men carry with them into sociological inquiries, the modes of observation and reasoning which they have been accustomed to in other inquiries—those of them, at least, who make any inquiries worthy to be so called. Passing over the great majority of the educated, and limiting ourselves to the very few who consciously collect data, compare them, and deliberately draw conclusions; we may see that even these have to struggle with the difficulty that the habits of thought generated by converse with relatively simple phenomena, partially unfit them for converse with these highly-complex phenomena. Faculty of every kind tends always to adjust itself to its work; special adjustment to one kind of work involves more or less non-adjustment to other kinds; and hence, intellects disciplined in dealing with less-involved classes of facts, cannot successfully deal with this most-involved class of facts without partially unlearning the methods they have learned.

From the emotional nature, too, there arise great obstacles. Scarcely any one can contemplate social arrangements and actions with the unconcern felt when contemplating arrangements and actions of other kinds. For correct observation and correct drawing of inferences, there needs the calmness that is ready to recognize or to infer one truth as readily as another. But it is next to impossible thus to deal with the truths of Sociology. In the search for them, each carries with him feelings, more or less strong, which make him eager to find this evidence, oblivious of that which is at variance with it, reluctant to draw any conclusion but that already drawn. And though perhaps one in ten among those who think, is conscious that his judgment is being warped by prejudice, yet even in him the warp is not adequately allowed for. It is true that in nearly every field of inquiry emotion is a perturbing intruder: mostly there is some preconception, and some *amour propre* that resists disproof of it. But the peculiarity of Sociology is, that the emotions with which its facts and conclusions are regarded, have unusual strength. The personal interests are directly affected, or there is gratification or offence to sentiments that have grown out of them; or else other sentiments which have relation to the existing form of society, are excited, agreeably or disagreeably.

And here we are introduced to the third kind of difficulty—that caused by the position occupied in respect to the phenomena to be generalized. In no other case has the inquirer to investigate the properties of an aggregate in which he is himself included. His relation toward the facts he here studies, we may figure to ourselves by comparing it to the relation between a single cell forming part of a living body, and the facts which that living body presents as a

whole. There is, indeed, nothing like so close a dependence of the unit upon the aggregate; but still there is a very decided dependence. Speaking generally, the citizen's life is made possible only by due performance of his function in the place he fills; and he cannot wholly free himself from the beliefs and sentiments generated by the vital connections hence arising between himself and his society. Here, then, is a difficulty to which no other science presents any thing analogous. To cut himself off in thought from all his relationships of race, and country, and citizenship—to get rid of all those interests, prejudices, likings, superstitions, generated in him by the life of his own society and his own time—to look on all the changes societies have undergone and are undergoing, without reference to nationality, or creed, or personal welfare; is what the average man cannot do at all, and what the exceptional can do very imperfectly.

The difficulties of the Social Science, thus indicated in vague outline, have now to be described and illustrated in detail.

V.—Objective Difficulties.

Along with much that has of late years been done toward changing primitive history into myth, and along with much that has been done toward changing once-unquestioned estimates of persons and events of past ages, much has been said about the untrustworthiness of historical evidence. Hence there will be ready acceptance of the statement that one of the impediments to sociological generalization, is the uncertainty of our data. When we bear in mind that from early stories such as those about the Amazons, their practices, the particular battles with them, and particular events in those battles, all of which are recorded and sculptured as circumstantially as they might be were the persons and events historic—when we bear in mind, I say, that from such early stories down to accounts of a well-known people like the New-Zealanders, who, "by some . . . . are said to be intelligent, cruel, and brave; by others, weak, kindly, and cowardly,"[1] we have to deal with an enormous accumulation of conflicting statements; we cannot but feel that the task of collecting facts from which to draw conclusions, is in this case a more arduous one than in any other case. Passing over remote illustrations, let us take an immediate one:

Last year advertisements announced the "Two-headed Nightingale;" and the walls of London were placarded with a figure in which one pair of shoulders was shown to bear two heads looking the same way (I do not refer to the later placards, which partially differed from the earlier). To some, this descriptive name and answering diagram seemed sufficiently exact; for in my hearing a lady, who had been to see this compound being, referred to the placards and handbills as giving a good representation. If we suppose this lady to have re-

[1] Thomson's "New Zealand," vol. i., p. 80.

peated in a letter that which I heard her say, and if we ask what would appear the character of the evidence to one who, some fifty years hence, had before him the advertisement, the representation, and the letter, we shall see that the alleged fact would be thought by him incontestable. Only if, after weary search through all the papers and periodicals of the time, he happened to come upon a certain number of the *Lancet*, would he discover that this combination was not that of two heads on one body, but that of two individuals united back to back, with heads facing opposite ways, and severally complete in all respects, except where the parts were so fused as to form a double pelvis, containing certain pelvic viscera common to the two. If, then, respecting facts of so simple and so easily-verifiable a kind, where no obvious motive for misrepresentations exists, we cannot count on true representations, how shall we count on true representations of social facts, which, being so diffused and so complex, are so difficult to observe, and in respect of which the perceptions are so much perverted by interests, and prepossessions, and party feelings?

In exemplifying this difficulty, let us limit ourselves to cases supplied by the life of our own time; leaving it to be inferred that if, in a comparatively calm and critical age, sociological evidence is vitiated by various influences, much more must there have been vitiation of such evidence in the past, when passions ran higher and credulity was greater.

Those who have lately become conscious of certain facts are apt to suppose those facts have lately arisen. After a changed state of mind has made us observant of occurrences we were before indifferent to, there often results the belief that such occurrences have become more common. It happens so even with accidents and diseases. Having lamed himself, a man is surprised to find how many lame people there are; and, becoming dyspeptic, he discovers that dyspepsia is much more frequent than he supposed when he was young. For a kindred reason he is prone to think that servants do not behave nearly so well as they did during his boyhood—not remembering that in Shakespeare's day the service obtainable was similarly reprobated in comparison with "the constant service of the antique world." Similarly, now that he has sons to establish in life, he fancies that the difficulty of getting places is much greater than it used to be.

As witnesses to social phenomena, men thus impressed by facts which did not before impress them, become perverters of evidence. Things they have suddenly recognized, they mistake for things that have suddenly come into existence; and so are led to regard as a growing evil or good, that which is as likely as not a diminishing evil or good. Take an example or two:

In generations not long passed away, sobriety was the exception rather than the rule: a man who had never been drunk was a rarity.

Condiments were used to stimulate drinking; glasses were so shaped that they would not stand, but must be held till emptied; and a man's worth was in part measured by the number of bottles he could take in. After a reaction had already greatly diminished the evil among the upper and middle ranks, there came an open recognition of the evil; resulting in Temperance Societies, which did their share toward further diminishing it. Then came the Teetotal Societies, more thoroughgoing in their views and more energetic in their actions, which have been making the evil still less; the accumulated effect of these causes being, that for a long time past among the upper classes, the drinking which was once creditable has become a disgrace; while among the lower classes it has greatly decreased, and come to be generally reprobated. Those, however, who, carrying on the agitations against it, have had their eyes more and more widely opened to the vice, assert or imply in their speeches and petitions that the vice is not only great but growing. Having in the course of a generation much mitigated it by their voluntary efforts, they now make themselves believe, and make others believe, that it is too gigantic to be dealt with otherwise than by repressive enactments—Maine Laws and Permissive-Prohibitory Bills. And, if we are to be guided by a Select Committee which has just reported, fines and imprisonments for drunkenness must be made far more severe than now, and reformatories must be established in which inebriates shall be dealt with much as criminals are dealt with.

Take, again, the case of education. Go back far enough, and you find nobles not only incapable of reading and writing, but treating these accomplishments with contempt. Go back not quite so far, and you find, along with a slight encouragement by authority of such learning as referred to Theology, a positive discouragement of all other learning;[1] joined with the belief that only for the clergy is learning of any kind proper. Go back a much smaller distance, and you find in the highest classes inability to spell tolerably, joined with more or less of the feeling that good spelling was a pedantry improper for ladies—a feeling akin to that named by Shakespeare as shown by those who counted it "a meanness to write fair." Down even to quite modern times, well-to-do farmers and others of their rank were by no means all of them able to read and write. Education, spreading thus slowly during so many centuries, has during the last century spread with comparative rapidity. Since Raikes commenced Sunday-schools in 1771; since Lancaster, the Quaker, in 1796 set up the first of the schools that afterward went by his name; since 1811, when the Church had to cease its opposition and become a competitor in educating poor children; the strides have been enormous: a degree of ignorance which had continued the rule during so many centuries was made in the course of half a century the exception. And then in 1834, after

[1] Hallam's "Middle Ages," chap. ix., part ii.

this unobtrusive but speedy diffusion of knowledge, there came, along with a growing consciousness of the still-remaining deficiency, the system of State-subsidies; which, beginning with £20,000, grew, in less than thirty years, to more than a million. Yet now, after this vast progress at an ever-increasing rate, there has come the outcry that the nation is perishing for lack of knowledge. Any one not knowing the past, and judging from the statements of those who have been urging on educational organizations, would suppose that strenuous efforts are imperative to save the people from some gulf of demoralization and crime, into which ignorance is sweeping them.

How testimonies respecting objective facts are thus perverted by the subjective states of the witnesses, and how we have to be ever on our guard against this cause of vitiation in sociological evidence, may indeed be inferred from the illusions that daily mislead men in their comparisons of past with present. Returning after many years to the place of his boyhood, and finding how insignificant are the buildings he remembered as so imposing, every one discovers that in this case it was not that the past was so grand, but that his impressibility was so great and his power of criticism so small. He does not perceive, however, that the like holds generally; and that the apparent decline in various things is really due to the widening of his experiences and the growth of a judgment no longer so easily satisfied. Hence the mass of witnesses may be under the impression that there is going on a change just the reverse of that which is really going on; as we see, for example, in the notion current in every age, that the size and strength of the race have been decreasing, when, as proved by bones, by mummies, and by armor, and by the experiences of travellers in contact with aboriginal races, they have been on the average increasing.

Most testimony, then, on which we have to form ideas of sociological states, past and present, has to be discounted to meet this cause of error; and the rate of discount has to be varied according to the epoch, and the subject, and the witness.

Beyond this vitiation of sociological evidence by general subjective states of the witnesses, there are vitiations due to more special subjective states. Of these, the first to be noted are those which foregone conclusions produce.

Extreme cases are furnished by fanatical agitators, such as members of the Anti-Tobacco Society, in the account of whose late meeting we read that "statistics of heart-disease, of insanity, of paralysis, and the diminished bulk and stature of the population of both sexes proved, according to the report, that these diseases were attributable to the use of tobacco." But without making much of instances so glaring as this, we may find abundant proof that evidence is in most cases unconsciously distorted by the pet theories of those who give it.

Early in the history of our sanitary legislation, a leading officer of

health, wishing to show the need for those measures he advocated, drew a comparison between the rate of mortality in some most salubrious village (in Cumberland, I think it was), and the rate of mortality in London; and then, pointing out the marked difference, alleged that this difference was due to "preventible causes"—to causes, that is, which good sanitary administration would exclude. Ignoring the fact that the carbonic acid exhaled by nearly three millions of people and by their fires, caused in the one case a vitiation of the air which in the other case did not exist—ignoring the fact that most city-occupations are of necessity in-door, and many of them sedentary, while the occupations of village life are out-of-door and active—ignoring the fact that in many of the Londoners the activities are cerebral in a degree beyond that to which the constitution of the race is adapted, while in the villagers the activities are bodily, in a degree appropriate to the constitution of the race; he set down the whole difference in the death-rate to causes of the kind which laws and officials might get rid of.

A still more marked example of this effect of a cherished hypothesis in vitiating the evidence given by an inquirer, was once unconsciously yielded to me by another enthusiast for sanitary regulation. Producing his papers, he pointed out a statistical contrast he had been drawing between the number of deaths *per annum* in the small town near London where he lived, and the number of deaths *per annum* in a low district of London—Bermondsey, or Lambeth, or some region on the Surrey side. On this great contrast he triumphantly dilated as proving how much could be done by good drainage, ventilation, etc. On the one hand, he passed over the fact that this small suburban town was, in large measure, inhabited by a picked population—people of means, well fed and clothed, able to secure all appliances of comfort, leading regular and quiet lives, free from overwork and anxiety. On the other hand, he passed over the fact that this low region of London was, by virtue of its lowness, one out of which all citizens pecuniarily able to take care of themselves escaped if they could, and into which were thrust an unusual number of those whose poverty excluded them from better regions—the ill-fed, the drunken, the dissolute, and others on the highway to death. Though, in the first case, the healthiness of the locality obviously drew to it an excess of persons otherwise likely to live long; and though, in the second case, the unhealthiness of the locality made it one in which an excess of those not likely to live long were left to dwell or brought to die; yet the whole difference was put down to direct physical effects of pure air and impure air respectively.

Statements proceeding from witnesses whose judgments are thus warped—statements republished by careless sub-editors, and readily accepted by the uncritical who believe all they see in print, diffuse erroneous prepossessions; which, again, tend to justify themselves by drawing the attention to confirmatory facts and away from facts that

are adverse. Throughout all past time vitiation of evidence by influences of this nature has been going on to a degree varying with each people and each age; and hence arises an additional obstacle to the obtainment of fit data.

Yet another, and perhaps stronger, distorting influence existing in the medium through which facts reach us, results from the self-seeking, pecuniary or other, of those who testify. We require constantly to bear in mind that personal interests affect most of the statements on which sociological conclusions are based, and on which legislation proceeds.

Every one knows this to be so where the evidence concerns mercantile affairs. That railway enterprise, at first prompted by pressing needs for communication, presently came to be prompted by speculators, professional and financial; and that the estimates of cost, of traffic, of profits, etc., set forth in prospectuses, were grossly misleading; many readers have been taught by bitter experience. That the gains secured by schemers who float companies have fostered an organized system which has made the falsification of evidence a business, and which, in the case of bubble insurance companies, has been worked so methodically that it has become the function of a journal to expose the frauds continually repeated, are also familiar facts; reminding us how in these directions it is needful to look very skeptically on the allegations put before us. But there is not so distinct a consciousness that in other than business enterprises, self-seeking is an active cause of misrepresentation.

Like the getting up of companies, the getting up of agitations and of societies has become, to a considerable extent, a means of advancement. As in the United States politics has become a profession, into which a man enters to get an income, so here there has grown up, though happily to a smaller extent, a professional philanthropy, pursued with a view either to position, or to profit, or to both. Much as the young clergyman in want of a benefice, feeling deeply the spiritual destitution of a suburb that has grown beyond churches, busies himself in raising funds to build a church, and probably does not, during his canvass, understate the evils to be remedied; so every here and there an educated man with plenty of leisure and small income, greatly impressed with some social evil to be remedied or benefit to be achieved, becomes the nucleus to an institution, or the spur to a movement. And since his success depends mainly on the strength of the case he makes out, it is not to be expected that the evils to be dealt with will be faintly pictured, or that he will insist very strongly upon facts adverse to his plan. As I can personally testify, there are those who, having been active in getting up schemes for alleged beneficial public ends, consider themselves aggrieved when not afterward appointed salaried officials. The recent exposure of the "Free Dormitory Association," which, as stated at a meeting of the Charity-Organi-

zation Society, was but one of a class, shows what this process may end in. And the vitiation of evidence is an inevitable concomitant. One whom I have known during his thirty years' experience of Leagues, Alliances, Unions, etc., for various purposes, writes: "Like religious bodies, they (Associations) form creeds, and every adherent is expected to cry up the shibboleth of his party. . . . All facts are distorted to the aid of their own views, and such as cannot be distorted are suppressed. . . . In every association with which I have had any connection, this fraud has been practised."

The like holds in political agitations. Unfortunately, agencies established to get remedies for crying evils, are liable to become agencies maintained and worked in a considerable degree, and sometimes chiefly, for the benefit of those who reap incomes from them. An amusing instance of this was furnished, not many years ago, to a Member of Parliament who took an active part in advocating a certain radical measure which had for some years been making way, and which then seemed not unlikely to be carried. Being a member of the Association that had pushed forward this measure, he happened to step into its offices just before a debate which was expected to end in a majority for the bill, and he found the secretary and his subs in a state of consternation at the prospect of their success: feeling, as they obviously did, that their occupation was in danger.

Clearly, then, where personal interests come into play, there must be, even in men intending to be truthful, a great readiness to see the facts which it is convenient to see, and such reluctance to see opposite facts as will prevent much activity in seeking for them. Hence a large discount has mostly to be made from the evidence furnished by institutions and societies in justification of the policies they pursue or advocate. And since much of the evidence respecting both past and present social phenomena comes to us through agencies calculated thus to pervert it, there is here a further impediment to clear vision of facts.

That the reader may fully appreciate the difficulties which these distorting influences, when combined, put in the way of getting good materials for generalization, let him contemplate a case:

All who are acquainted with such matters know that, up to some ten years since, it was habitually asserted by lecturers when addressing students, and by writers in medical journals, that, in our day, syphilis is a far less serious evil than it was in days gone by. Until quite recently this was a commonplace statement, called in question by no one in the profession. But just as, while a gradual decrease of drunkenness has been going on, Temperance-fanatics have raised an increasing outcry for strenuous measures to put down drunkenness; so, while venereal disease has been diminishing in frequency and severity, certain instrumentalities and agencies have created a belief that rigorous

measures are required to check its progress. This incongruity would by itself be a sufficient proof of the extent to which, on the one side or the other, evidence must have been vitiated. What, then, shall we say of the incongruity on finding that the first of these statements has recently been repeated by many of the highest medical authorities, as one verified by their experience? Here are some of their testimonies:

The Chairman of the late Government Commission for inquiring into the treatment and prevention of syphilis, Mr. Skey, Consulting-Surgeon to St. Bartholomew's Hospital, gave evidence before a House of Lords Committee. Referring to an article expressing the views of the Association for promoting the extension of the Contagious Diseases Acts, he said it was—

"largely overcharged," and "colored too highly. . . . The disease is by no means so common or universal, I may say, as is represented in that article, ... and I have had an opportunity, since I had the summons to appear here to-day, of communicating with several leading members in the profession at the College of Surgeons, and we are all of the same opinion, that the evil is not so large by any means as it is represented by the Association."

Mr. John Simon, F. R. S., for thirty-five years a hospital surgeon, and now Medical Officer to the Privy Council, writes in his official capacity:

"I have not the least disposition to deny that venereal affections constitute a real and great evil for the community; though I suspect that very exaggerated opinions are current as to their diffusion and malignity."

By the late Prof. Syme it was asserted that—

"It is now fully ascertained that the poison of the present day (true syphilis) does not give rise to the dreadful consequences which have been mentioned, when treated without mercury. . . . None of the serious effects tha used to be so much dreaded ever appear, and even the trivial ones just noticed comparatively seldom present themselves. We must, therefore, conclude either that the virulence of the poison is worn out, or that the effects formerly attributed to it depended on treatment."[1]

The *British and Foreign Medico-Chirurgical Review*, which stands far higher than any other medical journal, and is friendly to the Acts as applied to military and naval stations, writes thus:

"The majority of those who have undergone the disease, thus far" (including secondary manifestations), "live as long as they could otherwise have expected to live, and die of diseases with which syphilis has no more to do than the man in the moon."[2] . . . . "Surely 455 persons suffering from true syphilis in one form or another, in a poor population of 1,500,000" (less than one in 3,000) . . . . "cannot be held to be a proportion so large as to call for exceptional action on the part of any government."[3]

[1] "Principles of Surgery." Fifth edition, p. 434.

[2] *British and Foreign Medico-Chirurgical Review*, January, 1870, p. 103.

[3] Ibid., p. 106.

Mr. Holmes Coote, F. R. C. S., Surgeon and Lecturer on Surgery at St. Bartholomew's Hospital, says:

"It is a lamentable truth that the troubles which respectable, hard-working married women of the working-class undergo are more trying to the health, and detrimental to the looks, than any of the irregularities of the harlot's career."

Again, it is stated by Mr. Byrne, Surgeon to the Dublin Lock Hospital, that "there is not nearly so much syphilis as there used to be;" and, after describing some of the serious results that were once common, he adds: "You will not see such a case for years—a fact that no medical man can have failed to remark." Mr. W. Burns Thompson, F. R. C. S., for ten years head of the Edinburgh Dispensary, testifies as follows:

"I have had good opportunities of knowing the prevailing diseases, and I can only say that the representations given by the advocates of these Acts are to me perfectly unintelligible; they seem to me to be gross exaggeration."

Mr. Surgeon-Major Wyatt, of the Coldstream Guards, when examined by the Lords' Committee, stated that he quite concurred with Mr. Skey. Answering question 700, he said:

"The class of syphilitic diseases which we see are of a very mild character; and, in fact, none of the ravages which used formerly to be committed on the appearance and aspect of the men are now to be seen. . . . It is an undoubted fact that in this country and in France the character of the disease is much diminished in intensity.—*Question:* 708. I understand you to say, that in your opinion the venereal disease has generally, independent of the Act, become more mitigated, and of a milder type? *Answer:* Yes; that is the experience of all surgeons, both civil and military."

Dr. Druitt, President of the Association of the Medical Officers of Health for London, affirmed at one of its meetings—

"that speaking from thirty-nine years' experience, he was in a position to say that cases of syphilis in London were rare among the middle and better classes, and soon got over."

And even Mr. Acton, a specialist, to whom more than to any other man the Acts are due, admitted before the Lords' Committee that "the disease is milder than it was formerly."

Like testimony is given by Continental surgeons, among whom it was long ago said by Ambrose Paré, that the disease "is evidently becoming milder every day;" and by Auzias Turenne, that "it is on the wane all over Europe." Astruc and Diday concur in this statement. And the latest authority on syphilis, Lancereaux, whose work is so valued that it has been translated by the Sydenham Society, asserts that—

"In these cases, which are far from being rare, syphilis is but an abortive disease; slight and benignant, it does not leave behind any troublesome trace of

its passage. It is impossible to lay too much stress upon this point. At the present day especially, when syphilis still inspires exaggerated fears, it should be known that this disease becomes dissipated completely in a great number of cases after the cessation of the cutaneous eruptions, and perhaps sometimes even with the primary lesion."[1]

It will, perhaps, be remarked that these testimonies of medical men who, by their generally high position, or their lengthened experience, or their special experience, are so well qualified to judge, are selected testimonies; and against them will be set the testimonies of Sir James Paget, Sir W. Jenner, and Mr. Prescott Hewett, who regard the evil as a very grave one. To gather accurately the *consensus* of medical opinion would be impracticable without polling the whole body of physicians and surgeons; but we have a means of judging which view most truly meets with "the emphatic concurrence of numerous practitioners:" that, namely, of taking a local group of medical men. Out of fifty-eight physicians and surgeons residing in Nottingham and its suburbs, fifty-four have put their signatures to a public statement that syphilis is "very much diminished in frequency, and so much milder in form that we can scarcely recognize it as the disease described by our forefathers." And among these are the medical men occupying nearly all the official medical positions in the town—Senior Physician to the General Hospital, Honorary Surgeon ditto, Surgeons to the Jail, to the General Dispensary, to the Free Hospital, to the Union Hospital, to the Lock Hospital (four in number), Medical Officers to the Board of Health, to the Union, to the County Asylum, etc., etc. Even while I write there comes to me kindred evidence in the shape of a letter published in the *British Medical Journal* for July 20, 1872, by Dr. Carter, Honorary Physician to the Liverpool Southern Hospital, who states that, after several debates at the Liverpool Medical Institution, "a form of petition strongly condemnatory of the Acts was written out by myself, and . . . . in a few days one hundred and eight signatures" (of medical men) "were obtained." Meanwhile, he adds, "earnest efforts were being made by a number of gentlemen to procure medical signatures to the petition in favor of the Acts known as the 'London Memorial'—efforts which resulted in twenty-nine signatures only."

Yet notwithstanding this testimony great in quantity, and much of it of the highest quality, it has been possible so to present the evidence as to produce in the public mind, and in the Legislature, the impression that peremptory measures for dealing with a spreading pest are indispensable. As lately writes a Member of Parliament:

[1] "A Treatise on Syphilis," by Dr. E. Lancereaux, vol. ii., p. 120. This testimony I quote from the work itself, and have similarly taken from the original sources the statements of Skey, Simon, Wyatt, Acton, and the *British and Foreign Medico-Chirurgical Review*. The rest, with various others, will be found in the pamphlet of Dr. C. B. Taylor on "The Contagious Diseases Acts."

"We are assured, on what appeared unexceptionable testimony, that a terrible constitutional disease was undermining the health and vigor of the nation, and especially destroying innocent women and children."

And then note the startling circumstance that while so erroneous a conception of the facts may be spread abroad, there may, by the consequent alarm, be produced a blindness to facts of the most unquestionable kind, established by the ever-accumulating experiences of successive generations. Until quite recently, our forms of judicial procedure embodied the principle that some overt injury must be committed before legal instrumentalities can be brought into play; and conformity to this principle was in past times gradually brought about by efforts to avoid the terrific evils that otherwise arose. As a Professor of Jurisprudence reminds us, "the object of the whole complicated system of checks and guards provided by English law, and secured by a long train of constitutional conflicts, has been to prevent an innocent man being even momentarily treated as a thief, a murderer, or other criminal, on the mere alleged or real suspicion of a policeman." Yet now, in the state of groundless fright that has been got up, "the concern hitherto exhibited by the Legislature for the personal liberty of the meanest citizen has been needlessly and recklessly lost sight of."[1] It is an *a priori* inference from human nature that irresponsible power is sure, on the average of cases, to be grossly abused. The histories of all nations, through all times, teem with proofs that irresponsible power has been grossly abused. The growth of representative governments is the growth of arrangements made to prevent the gross abuse of irresponsible power. Each of our political struggles, ending in a further development of free institutions, has been made to put an end to some particular gross abuse of irresponsible power. Yet the facts thrust upon us by our daily experiences of men, verifying the experiences of the whole human race throughout the past, are now tacitly denied; and it is tacitly asserted that irresponsible power will not be grossly abused. And all because of a manufactured panic about a decreasing disease, which kills not one-fifteenth of the number killed by scarlet fever, and which takes ten years to destroy as many as diarrhœa destroys in one year.

See, then, what we have to guard against in collecting sociological data—even data concerning the present, and, still more, data concerning the past. For testimonies that come down to us respecting bygone social states, political, religious, judicial, physical, moral, etc., and respecting the actions of particular causes on those social states, have been liable to perversions not simply as great, but greater; since, while the regard for truth was less, there was more readiness to accept unproved statements.

[1] Prof. Sheldon Amos. See also his late important work, "A Systematic View of the Science of Jurisprudence," pp. 119, 303, 512, 514.

Even where deliberate measures are taken to obtain valid evidence on any political or social question raised, by summoning witnesses of all classes and interests, there is difficulty in getting at the truth; because the circumstances of the inquiry tend of themselves to bring into sight some kinds of evidence, and to keep out of sight other kinds. In illustration may be quoted the following statement of Lord Lincoln on making his motion concerning the enclosures of commons:

"This I know, that in nineteen cases out of twenty, committees sitting in this House on private bills neglected the rights of the poor. I do not say that they wilfully neglected those rights—far from it; but this I affirm, that they were neglected in consequence of the committees being permitted to remain in ignorance of the rights of the poor man, because by reason of his very poverty he is unable to come up to London to fee counsel, to procure witnesses, and to urge his claims before a committee of this House."—(*Hansard*, May 1, 1845.[1])

Many influences of a different order, but similarly tending to exclude particular classes of facts pertinent to an inquiry, come into play. Given a question at issue, and it will very probably happen that witnesses on the one side may, by evidence of a certain nature, endanger a system on which they depend for the whole or for part of their livelihood; and by evidence of an opposite nature may preserve it. By one kind of testimony they may offend their superiors and risk their promotion: doing the reverse by another kind. Moreover, witnesses not thus directly interested are liable to be indirectly swayed by the thought that to name certain facts they know will bring on them the ill-will of important persons in their locality—a serious consideration in a provincial town. And while such influences strongly tend to bring out evidence, say in support of some established organization, there may very possibly, and, indeed, very probably, be no organized adverse interest with abundant resources which busies itself to bring out a contrary class of facts—no occupation in danger, no promotion to be had, no applause to be gained, no odium to be escaped. Contrariwise, there may be positive sacrifices, serious in amount, to be made before such contrary class of facts can be brought to light. And thus it may happen that, perfectly open and fair as the inquiry seems, the circumstances will insure a one-sided representation.

A familiar optical illusion well illustrates the nature of these illusions which often deceive sociological inquirers: When standing by a lake-side in the moonlight, you see, stretching over the rippled surface toward the moon, a bar of light which, as shown by its nearer part, consists of flashes from the sides of separate wavelets. You walk, and the bar of light seems to go with you. There are, even among cultivated people, many who suppose that this bar of light has an objective

[1] Quoted by Nasse, "The Agricultural Community of the Middle Ages," etc., English translation, p. 94.

existence, and who believe that it really moves as the observer moves—occasionally, indeed, as I can testify, expressing surprise at the fact. But, apart from the observer, there exists no such bar of light; nor when the observer moves is there any movement of this glittering line of wavelets. All over the dark part of the surface the undulations are just as bright with moonlight as those he sees; but the light reflected from them does not reach his eyes. Thus, though there seems to be a lighting of some wavelets and not of the rest, and though, as the observer moves, other wavelets seem to become lighted that were not lighted before, yet both these are utterly false seemings. The simple fact is, that his position in relation to certain wavelets brings into view their reflections of the moon's light, while it keeps out of view the like reflections from all other wavelets.

Sociological evidence is largely vitiated by illusions thus caused. Habitually the relations of observers to the facts are such as make visible the special, and exceptional, and sensational, and leave invisible the commonplace and uninteresting, which form the great body of the facts. And this, which is a general cause of deceptive appearances, is variously aided by those more special causes above indicated; which conspire to make the media, through which the facts are seen, transparent in respect of some and opaque in respect of others.

A GLASS OF WATER.

By FRIEDRICH MOHR.[1]

IN tracing the history of the civilization and growth of humanity, it becomes noticeable that long periods of time often witness but slow and gradual progress; but that from time to time a few inventions and discoveries of eminent men suddenly kindle a revolution in all the spheres of human affairs. To trace to their source the changes so wrought, presents to the historian and scientist one of the most interesting subjects. In nearly every place, the most ancient of such great events, the invention of language and of written characters, are wrapped in complete darkness. As history can be handed down to posterity by means of language only, it is obvious that ages without language can have no history. It is language which introduces nations into history. As regards written speech the case is somewhat different. The most distinguished people of antiquity, the Greeks, emerged from obscurity into history with a language wonderfully complete, but without written characters. During several centuries the Homeric songs had to wan-

[1] Translated from the German, by C. L. Hotze, Teacher of Physics and Chemistry in the High School of Cleveland, Ohio.

der from mouth to mouth before they were intrusted to the graphic symbols; from this moment they disappeared from memory. Written language is the downfall of tradition.

The history of the rise of the two great races of antiquity, the Greek and the Roman, is barren of important inventions. Their blue sky made them wellnigh independent of Nature. Amid the cheerful enjoyment of the natural, intellect in Greece flourished as never before or afterward in any clime; the age of Pericles—

> "The age of godlike fantasy,
> Is vanished, never to return."

The palmy days soon passed away, however; the mountainous land of small extent succumbed first to the Macedonian, then to the Roman victor. The descendants of the conquerors of Asia became private teachers to the Roman grandees.

Rome herself developed into political greatness only. With the exception of her historians, her scientific lustre was merely a faint image of Grecian culture, very much like German literature of the first half of the eighteenth century when compared with the times of Louis XIV. and Queen Anne. No remarkable invention, of lasting benefit to humanity, sprang from the Romans. Even the weapons of war, down to the invention of gunpowder, remained the same as when Glaucus and Diomedes handled them. Shield, spear, and sword, had changed shape and size, but none of their functions.

Not until the invention of gunpowder was the aspect of society essentially changed. A bit of charcoal, a nitre-crystal, and a few grains of sulphur mixed together, made up a powder that rent mountains and crushed walls. At once all the then prevailing systems of attack and defence were overthrown. The nation most advanced in technical matters became the most powerful. With a few thousand blunderbusses, a handful of adventurers conquered a new continent. The history of the invention of gunpowder is as yet a myth. Very likely, an accident was the main cause. Science claims no reward. Then came a series of inventions and discoveries, each of which played an important part in framing society anew. The compass emboldened the mariner to leave the coast for the open sea, and helped to discover a new continent and circumnavigate an old one; the telescope revealed celestial spaces hitherto unknown; the laws of the pendulum, discovered at that epoch, the laws of compressed air, of the circulation of the blood, of the motions of the planets, furnished important building-material with which to rear culture and civilization. The newly-invented art of printing rendered the sources of knowledge accessible to all. Our purpose is not to unfold all this in detail; but it was necessary to show the distances of those stopping-points where history changes horses in order to go forward with renewed vigor. With the invention of printing, history commenced making more rapid strides. A

few centuries later, however, events occurred which were originated and put upon the scene by means of the art of printing, and which greatly diminished the blessings of the invention on account of the almost total destruction of national prosperity during the Thirty Years' War. The art itself meanwhile had not improved. The prints of those times are poor and wretched compared with the excellent works of Guttenberg. The importance of the art by far exceeds its intellectual merit. Many inventions have since been made, which involve far higher intellectual endowments than the invention of printing. The Jacquard loom, the stocking-frame, the carding-machine, the watch, the chronometer, and other inventions, unquestionably involve rarer gifts of combination and executive force; yet, as regards influence, none of them can even remotely be compared with the printing-press; none would at that time have come to light without the press.

This vast capital handed down to us by former generations, modern humanity has immeasurably increased, even doubled and trebled. The inventions and discoveries mentioned thus far are fully known, as to their immense bearing upon the direction of human life.

In addition to these, let us record two events of the second half of the last century, which, more promptly and thoroughly than even any of the preceding, changed the entire social conditions of humanity: one an invention, that of the steam-engine; the other a discovery, that of oxygen.

The importance of the steam-engine requires no comment. Man derives power from the rays of the sun which were stored up as carbon in the vegetable kingdom from time immemorial. The steam which to-day gushes from the locomotive is an equivalent of the rays that decomposed the carbonic acid of the huge marine plants of those early periods, and accumulated the carbon as a source of power—a sleeping affinity, a lifted weight. In combining this carbon again with oxygen, we produce precisely as much heat as disappeared during the growth of those plants. The steam generated by this heat we allow to push against a movable obstacle, and to this obstacle we attach the resistances to be overcome—a train of cars, a number of looms or hammers, grindstones or rolls. The power is neither given us nor is it generated. It disappears with the wood or the coal.

The discovery of oxygen has an altogether different importance. We are confronted by an apparently insignificant fact which Destiny seemed for a time to have permanently assigned to the chemist's laboratory. It was on the 1st of August, in 1774, that Priestley, an English clergyman and a naturalist, for the first time performed the celebrated experiment which up to the present day is repeated in nearly every course of lectures on experimental chemistry. He heated red oxide of mercury in a small glass retort, and obtained an invisible, colorless gas together with drops of liquid mercury. To collect the gas he employed the same means which we still use to-day. He took

a *glass*, filled and inverted it under water, and lifted it inverted so that it remained full on the surface of the water. Then he made the new gas pass through a tube and rise under the glass; the ascending bubbles soon filled the vessel with the pure gas. Thus he had oxygen collected in a *glass of water;* he held the microcosm in his grasp, and could investigate its properties. Almost at the same time the gas was discovered by the Swede Scheele, who prepared it by heating oxide of manganese. This was but one step, however; the substance that was to initiate a new era in the world was discovered but not yet recognized. As yet an error swayed the mind of man.

The phenomenon of combustion which, at the present time, is ascribed to the chemical union of oxygen with combustible bodies, was at that time explained as due to the escape of an unknown *fire-substance* called *phlogiston.* The products of combustion were said to be *dephlogisticated.* That substance was thought to escape from the burning body during the act of combustion; and yet experience demonstrated that the result of the combustion, such as, for example, the rusts of lead, zinc, and copper, had more weight than the original metals. In reply to this, it was maintained that the phlogiston possessed negative weight (that it buoyed up the substances on account of its *levity*). Thus error begat error. At length the mystery was solved by Lavoisier. He distinctly recognized the nature of oxygen as that of a simple body, and asserted that combustion was the combination of a substance with oxygen. This introduced the element into chemistry, a conception which formed at once the basis of an exact science. Priestley was the Copernicus of Chemistry, Lavoisier became its Kepler.

An immense number of familiar facts now easily clustered around this fundamental conception; and the so-called *antiphlogistic system* sprang into life, a system which has prevailed up to this day, although its name is no longer in use, there being no purpose in maintaining a term that would perpetuate the memory of an error.

The system met with the fate of that of Copernicus; after a protracted struggle it came out victorious, the tenet of every naturalist now living. Oxygen being the most frequently-occurring substance, entering into combinations with all bodies, forming eight-ninths of the weight of water, and over one-half the mass of our globe, and being the conspicuous element ever present in the phenomena of combustion and respiration—it was eminently the substance to establish the new system everywhere. More than half the science of chemistry is taken up by oxygen and its compounds. Priestley and Scheele, its discoverers, remained to the ends of their lives enemies to the new theory. On the 16th of Floreal, in the year II. of the French Republic, Lavoisier was compelled to lay his head under the guillotine.

The composition of water was discovered by Cavendish. This completed the antiphlogistic system. Water consists of two gases,

oxygen and hydrogen, which, with the characteristics of combustion, combine to form the well-known liquid. This fact was of such paramount importance, that at great expense a whole *glass of water* was produced by combustion, and the water was shown to possess the identical properties of pure rain-water.

In the beginning, chemistry, being still a young science, had to attend to domestic arrangements. It must first obtain the substances and contrive the apparatus wherewith to explore the natures of the various bodies composing our globe. A celebrated period soon followed, during which every number of a scientific journal would be filled with important and most momentous discoveries. So glorious an epoch as this probably never before occurred in the history of mankind. New elements, new compounds, were discovered—unknown compounds separated into their component elements. The discovery of the alkaline metals and earths was an event which astonished the world. The natures of such bodies as would not yield to analysis were divined, and subsequent experimentation has verified the speculations. Thus the presence of a metal in clay, lime, and quartz, was distinctly foretold; fifty years later it was actually produced.

The consequences of any discovery are incalculable. Davy investigated the nature of the flame, and communicated his discoveries in a lecture before a large audience. He demonstrated that it was within our power to produce a flame which, at a state of extreme heat, contained either free oxygen or unburnt carbon; that a large grate with a limited supply of coal would generate the former, the oxidizing flame, while a small grate with a larger amount of coal would yield the other, the flame devoid of oxygen, but in which combustible substances might be melted without the danger of combustion. Among the hearers sat a young man by the name of Cort, who directed his mind to these remarks. Up to that time cast-iron was converted into wrought-iron by heating it with charcoal and exposing the melted metal to a blast of air. By this process only small quantities of wrought-iron were obtained at a time, through the necessity of producing but one *bloom* in a heat, which might easily be hammered out; and also on account of the cost of charcoal. In this process mineral coal could not be placed in contact with the iron, because the never-failing presence of sulphur in that kind of coal would render the iron unfit for use. From Davy's lecture on the flame, Cort struck upon the idea of decarbonizing cast-iron without exposing it to the danger of the contact with coal, by allowing the flames only of the coal to play upon the cast-iron. Thus originated that wonderful operation called the *puddling process.* Large quantities of cast-iron are melted on the floor of a reverberatory furnace (so named from having an arch which throws the flame back on the iron), and a portion of the carbon in the iron is burnt up by the oxidizing flame; as soon as the iron passes from the liquid state to a pasty condition, the puddler rakes it by

means of a long iron bar called a *paddle*, and finally separates the whole mass of iron into large lumps, each weighing from 60 pounds upward. After this, the opening in the door of the furnace is closed, and the hot oxidizing flame allowed to impinge upon the balls until they are completely converted into bar-iron. The balls are then placed under a hammer; and, the melted slag being forced out, they are rolled into bars between the *puddling-rolls*.

The ancient mode of refining iron needed no rolls, a hammer was sufficient; nowadays, the huge quantities of refined iron turned out by the puddling-furnace require more than a hammer. The invention of the puddling-rolls was the natural sequence of the puddling-furnace. This furnace yields more than a hundred times the quantity of bar-iron produced by the bloomery of former times; and the *blooms* —or balls—can be made of a size sufficient to be turned into iron rails of from 16 to 24 feet in length.

At this point let us cast a glance upon the past. We are contemporaries of the great discovery which shortens the distances upon the globe. About forty years have passed since the first locomotive dashed over the track, and already our social and political conditions are mainly dependent on this invention. Not many years ago, a whole army was conveyed from the southern part of Germany to the north within a few days, and this without a straggler—an operation formerly requiring months. In 1866 we saw how an army, equal in size to the one that perished in Russia in 1812, started from the farthermost limits of Germany, was moved in a very short period to another field, and arrived there at the appointed time. Within a day or so, Germany or France can be passed over in its longest extent. The rapid supply of local wants by the importation of grain and cattle acts most powerfully upon the stability of prices. A famine, in the proper sense of the word, can scarcely be thought of at the present time, unless it be a universal famine. Fresh sea-produce, which formerly gladdened only the coast-land, penetrates now into the interior. Districts far remote from the commerce of the earth, but crossed by the iron track, can now take their produce to the great markets of the world. Hence it cannot be denied that the form of modern society depends upon the railroads. But where would our railroads be if we could not roll rails? Where the rails, if we had no puddling-furnace? Where the puddling-furnace, without a knowledge of the flame? And this knowledge is simply the result of the study of chemical science, which, in turn, may be traced back to the discovery of oxygen. This whole series of wonderful effects and causes dates from that *glass of water* in which Priestley first collected oxygen. Not a member of that series could have been passed by, not a link of that chain been wanting, without rendering impossible the remaining links. It can be asserted fearlessly, that the favorable condition of modern society has its rise in the discovery of oxygen.

Let me here allude to those stupendous processes, the manufactures of sulphuric acid and of soda. To sketch the influence of chemistry upon life would carry us too far. Glass and soap are better to-day, and, despite their hundred-fold increased consumption, no dearer than in former times. Chlorine, as a bleaching agent, in place of the sun, has restored to agriculture thousands of acres of meadow-land.

But the powerful impulse carried also the kindred sciences. The Italian physician Galvani accidentally noticed the convulsions of a frog recently killed, whenever he touched him with two metals in contact with each other. This observation became the starting-point of the electric telegraph. The experiments of *Volta* resulted in the pile named after him. Two heterogeneous metals, such as zinc and copper, are immersed in a *glass of water*, to which a few drops of sulphuric acid have been added; both metals we connect by means of a long wire, and then we find the wire possessed of a new force which can transmit a motion through the distance of a hundred miles and over. For a long time the voltaic pile had been the subject of unsuccessful experiments for the purpose of finding its relation to the magnet, to which, on account of its poles, it bears a certain resemblance. One day, Oersted, at a lecture in Copenhagen in 1819, noticed that a magnetic needle on his table was disturbed by a communicating wire that happened to pass over it. He removed the wire, and the needle resumed its polar direction; he then replaced the wire, and the needle again turned aside. Electro-magnetism was discovered. At once he recognized the immense bearing of the phenomenon, repeated the experiment in presence of the magistrate, a notary public, and other witnesses, and made a Latin affidavit; this places his name, for all time to come, among the benefactors of the human race. The advantage of his invention is enjoyed by all of us who daily read telegrams from distant parts of the world as if this rapid transmission of news were a matter of course. The wonder has become a fact of daily occurrence; it rises with us and accompanies us through the day. Do you ever consider that, without this discovery of Oersted, the telegraph would not exist?

We place thirty or forty *glasses of water* in adjacency, each containing a plate of zinc and one of copper, together with a small quantity of sulphuric acid; we join the vessels by means of metallic wires soldered to the opposite plates, and connect the two extreme plates of the series with the ground, the extreme zinc plate by a short wire, the last copper by, say, a hundred-mile wire. A slight pressure of the finger upon a knob supported by a spring, and a dash or dot is produced a hundred miles away; thought is transmitted to that distance by the electric current; it makes its own record, the recipient needs simply to read off the marks. And through still greater distances it may be flashed by what is termed *a relay*, so that there is no greater difficulty in forwarding a dispatch from New York to San Francisco than from New York to Boston.

The more securely chemistry had established its household, the more willingly were its services offered to its neighbors. In investigating the composition of minerals, an exact science was created out of our collections of specimens. What meaning had a mineral whose constituents were unknown, in which nothing was observable but what every layman could perceive, viz., color, hardness, and form? Owing to chemistry, mere knowledge about minerals ripened into the science of mineralogy; she induced basalt and granite to yield a *glass of water*, and taught the process of their formation.

Casual observations had shown that certain substances changed their color on exposure to light. This was especially the case with several silver compounds. The attempt to utilize this property resulted in the invention of photography. A film of albumen or collodion on a glass plate contains a material which, together with silver, makes up a substance sensitive to the action of light. Thus prepared, the glass plate is immersed in a *glass of water* containing an argentic solution. When the plate is exposed in an optical apparatus to the action of the luminous rays of an object, the result of this action is an image produced on the plate, though invisible to the eye. In the places acted upon by the light-rays, the connection between the constituents of the sensitive argentic substance is not dissolved entirely, but rendered very unstable. The additional action of an oxidizing agent, such as a ferrous salt or pyro-gallic acid, causes opaque metallic silver to be formed on the lighted parts of the image, and a reversed picture, the so-called negative, is produced. The plate is now dipped again into a *glass of water*, containing a substance which removes the last traces of the sensitive coating, leaving the darkened picture behind. In this way the negative is protected from any further influence of light. Of course, the picture is not recognizable, for the lights and shadows are reversed, but by the same process they can be reversed a second time. A sheet of paper is covered with albumen and thereby sensitized, then laid under the negative and exposed to the action of the sun. The parts of the paper under the darkened portions of the negative remain unchanged; those under the lighted portions are changed by the sunlight. On their withdrawing, by means of hyposulphite of soda, the sensitive substance remaining on the paper, a real picture of the object, the so-called positive, is obtained. This wonderful process of sun-drawing was also involved in the discovery of oxygen, albeit that accident and planless searching had much to do with it. Accident, however, was unthinkable, had not chemistry first defined the substances and their properties. In photography great use is made of iodine, an element existing in the ocean. An eminent chemist, Gay-Lussac, investigated and described this body, without which no photograph can be made. Who would have thought at that time that the violet vapors of iodine contained both an invaluable medicine and photography?

The most difficult task for chemistry was the investigation of the laws of life. All that was known in regard to this was, that the living organisms of the animal and vegetable kingdoms consisted of a few elements, say three or four, which were the same in both. The difference, then, in the manifold organisms of the kingdoms must needs be quantitative; and here the first want was an accurate method of analysis. This presented a difficult problem. The first successful experiments date back as far as 1809, but the method of determining weight was as yet so complicated and wasteful of time, and required so much skill and practice, that only a few substances could be analyzed. To investigate the two organic kingdoms with greater hope of success, an easier method of analysis must be found, and here we meet the name of a man whom Germany proudly calls her own.

To Justus Liebig belongs the merit of having discovered a method by which, without loss of accuracy, the whole process was greatly simplified, and of which he himself made extensive use. As his great teacher, Gay-Lussac, had done before him, he burned the organic substance to be analyzed, in a dry glass tube with oxide of copper, condensed the resultant water in an apparatus containing a water-absorbing salt, calcium chloride, and the resultant carbonic acid was absorbed in a *glass of water.* This last was a glass of a peculiar shape, with a clear liquid consisting of an aqueous solution of pure caustic potash. This glass of water, which has rendered such great services to humanity, bears the name of "Liebig's potash apparatus," and appears on his pictures as interwoven with the clouds of the higher regions, thus enabling the chemist to recognize the portrait even without the signature.

By that simplified method and by the aid of the labors of his many talented students, who now adorn most of the chairs of chemistry in Europe, as well as through the geniality of the master, the immense material from which he reared the structure of organic chemistry could be collected and properly used. Agricultural chemistry may be considered a part of organic chemistry; its province is to determine the laws of the growth of plants. The year 1840 is of the same importance in the history of the world as the years 1436, 1492, and 1774, which mark the invention of printing, the discovery of America, and that of oxygen.

A report upon the application of chemistry to agriculture, which Liebig had agreed to prepare for the British Association for the Advancement of Science, convinced him of the fact that the then existing views regarding this subject consisted mainly of errors. Instead, therefore, of reporting upon agricultural chemistry, he must first create the science. He demonstrated this in the ever-memorable report which may be said to contain nearly three-fourths of the agricultural chemistry of the present day. The immense materials collected by him and his assistants were of excellent service in this work, for they had

closely investigated almost all the familiar ingredients of animals and vegetables, and, after comparing them, induced the great laws of nutrition and the mutual dependency of the two orders. He found that plants derived their nutriment solely from inorganic substances, taking their carbon from carbonic acid, their nitrogen from ammonia, their hydrogen from water; that animals drew their sustenance from organic substances only; that vegetable albumen had the same composition as the albumen in the egg and the blood, and that its admission was the result of its being dissolved by digestion. He then first announced the theory that the inorganic constituents, the so-called *ashes*, played an important part in the growth of vegetables, and that without their presence no vegetable structure could subsist. Thousands of facts and results of experiments had previously existed, but no one had found the law. After Liebig's announcement and demonstration, it became the starting-point of a new science.

He has not been spared the struggles which Copernicus and Lavoisier had to encounter; yet it may now be said that the warfare has terminated in his favor. The ships searching for guano-islands on the coast of Peru and in the Pacific Ocean do so upon the advice of Liebig; the agricultural colleges and similar institutions which sprang from his breath, may now be counted by the dozen. He was the first to assert that the most important changes and revolutions in the history of the world arose from the destruction of the wealth of the soil; and that the conquerors of the savage hordes of Central Asia were forced to march on by the violation of a law of Nature. Now, since the change of habitations is an unavoidable, ever-occurring element in the world's history, he who must be considered the greater conqueror is the man who teaches humanity what to do in order not to fall again a prey to Nature's law. Attila and Alaric were driven onward unconsciously, because forced by a natural law; far superior, far more powerful, is the natural philosopher who unfolds the law and teaches how to obey it. More enduring than the supremacy of the Roman Empire is the influence of that knowledge which teaches man how he may live on a soil for an unlimited period of time and with ever-constant result.

All this the illustrious inquirer obtained from the accurate investigations of animal and vegetable bodies; but the results would not have been possible without the improved method of analysis contained in that glass of water.

The causes of great inventions and discoveries have always been small, the results always incalculable—as incalculable as those of the glass of water spilled at Queen Anne's court. The investigator of Nature, therefore, must value every observation, every new fact, for they may result in *a glass of water*.

HAS OUR CLIMATE CHANGED?[1]

By DANIEL DRAPER, Esq.,

DIRECTOR OF METEOROLOGICAL OBSERVATORY, CENTRAL PARK.

Does the Clearing of Land affect the Fall of Rain?

MUCH solicitude is publicly felt as regards the supposed diminished quantity of water which fell last year—a point of the highest concern. There is a general impression that this alleged deficiency was to such an amount as to endanger a due supply to New York for the current year. And not only this, it has also been asserted that for several years past there has been a steadily occurring diminution in the rainfall. While the quantity of water has thus been becoming less and less, the demand has been becoming greater. Not only has the population of the city increased, but also that of the suburban districts, which derive their supplies from the same water-gathering grounds that we do.

I therefore, supposed, since the registering rain gauge furnishes very reliable measures, that it would be useful to examine this subject critically. But, since we have had these gauges in operation only about three years, and as the investigation proved to be full of interest, I was led to draw upon other additional sources of information, selecting such as seemed to be of the most trustworthy kind. By the aid of these the examination has been extended as far back as 1836, and with the following results:

1. As respects the indications given by our own instruments, which may be thoroughly relied on, for the years 1869, 1870, 1871.

For the first of these years, 1869, the total rainfall was 46.82 inches, distributed as follows:

During the first quarter	15.06	inches.
" " second "	10.24	"
" " third "	7.72	"
" " fourth "	13.80	"
Total	46.82	inches.

For 1870 the total rainfall was 42.32 inches, distributed as follows:

During the first quarter	12.86	inches.
" " second "	10.29	"
" " third "	9.39	"
" " fourth "	9.78	"
Total	42.32	inches.

[1] Abstract from the Meteorological Report of Daniel Draper, Director of Meteorological Observatory, Central Park, to the Commissioners of Public Parks (1871).

For 1871 the total rainfall was 52.06 inches, distributed as follows:

During the first quarter	10.33	inches.
" " second "	14.12	"
" " third "	14.21	"
" " fourth "	13.40	"
Total	52.06	inches.

So far as these years are concerned, there does not appear any evidence of a decrease; on the contrary, in the last there is a very considerable excess over either of the others.

Extending our examination to preceding years, as far back as the beginning of 1836, and grouping those years into three periods, each of ten, and one of six years, the statement comes to this:

First period from 1835 to 1846	39.5	inches.
Second " " 1845 to 1856	47.0	"
Third " " 1855 to 1866	52.0	"
Fourth " " 1865 to 1872	52.0	"

This would make the annual rainfall, throughout these thirty-six years, 47.62 inches. That of the last three years is 47.06 inches. These numbers being substantially the same, it may be concluded that, though there are large variations from year to year, these on the whole will neutralize one another, when very long periods of time are considered.

In the foregoing table the numbers from 1836 to 1854 inclusive are derived from the observations made by the military officers at Fort Columbus, New York Harbor; those for the next twelve years are from the records of Prof. Morris in New York City; and the remainder are from the registers of this observatory. It is, of course, assumed that the rainfall at Fort Columbus, that in New York City, and that in the Central Park, are the same—an assumption which, I suppose, is under the circumstances admissible.

The amount of rainfall not only influences in a predominant manner the growth of plants, and therefore agricultural pursuits, determining the profitable cultivation of many different crops, it also exerts an influence on several manufacturing operations. If, therefore, the above statement be correct, no apprehension need be entertained of a permanent disturbance in these particulars. Although in the last 36 years great changes have been made in all those portions of the United States intervening between the Mississippi and the Atlantic Ocean, large surfaces having been cleared of the primeval forest, and brought under cultivation, their physical character and aspect having therefore been essentially altered, no corresponding diminution can nevertheless be traced in the mean amount of water that has fallen. On the contrary, there has been an actual increase. It appears, therefore, that the wide-spread public impression, that the clearing of lan diminishes the volume of rain, is not founded on fact, and in trutl

this is no more than might have been expected from a correct consideration of the meteorological circumstances under which rain is produced.

It is the belief of European meteorologists that the mean rainfall on the western portions of that continent varies little, if at all, when periods of many years are considered. In England there are rainfall records reaching back to 1677. Since 1725 these records are unbroken; at present there are more than 1,500 rain-gauge stations in that country. The Scotch observations extend to 1731, the Irish to 1791.

A discussion of the observations made at the Royal Observatory at Greenwich, in 1859, led to the conclusion that the annual fall of rain, as compared with that previous to 1815, was becoming smaller; but more extended observations, taken from gauges at stations widely separated, led to the opposite conclusion, viz., that there was a perfect compensation, the decrease at one place being compensated by the increase at another.

This conclusion was strikingly illustrated by the Continental observatories. The rainfall at Paris was found not to have altered in 130 years, and, though the observations of 50 years at Marseilles gave a decrease, those for 54 years at Milan gave an increase.

Even in the same locality this principle of compensation may be noticed. Thus the rainfall in England, in the ten years from 1850 to 1859, was found by Mr. Symons to be five per cent. less than during the previous 40 years, but during the following six years it was five per cent. above the mean of the preceding ten.

It may, however, be supposed, that conclusions which apply to the old settled countries of Europe, in which but few important topographical changes through agricultural or other operations have taken place for many years, will scarcely apply to America, wherein the clearing of land and agricultural surface changes have been occurring on a very extensive scale. The foregoing conclusions, however, show us how insignificant is the meteorological result which these variations produce.

The Available Supply of Water.

The actual supply of water does not depend on rainfall alone. It is diminished by evaporation and also by percolation. When the condition of the atmosphere is such that, either by reason of the heat, the prevalence of dry winds, and other such causes, the water that has fallen is exposed to rapid vaporization, the available supply necessarily becomes less.

As regards percolation, much depends on the rate at which the rain falls, and the contemporaneous condition of the surface of the ground. The supply may come so rapidly that there is not time for it to soak into the earth. In this manner the quantity that properly belongs to a whole month may fall in the course of a few hours, and, rushing over

the surface, may be lost. Again, if the surface be frozen, it may be impossible for the water to percolate into the ground, and, though it may descend in a more moderate manner, it may, in this as in the preceding case, be lost. Obviously, there are many causes of the kind which might be referred to; these, however, are sufficient to indicate the principle involved.

We have shown that agricultural conditions do not perceptibly affect the rainfall; they do, however, very powerfully influence what may be designated as the rain-waste. Thus, a growing plant vaporizes from its leaves an immense amount of water which its roots have abstracted from the ground. A sunflower will thus remove twenty ounces of water in a single day. There is in this respect a waste which varies in the different months, being greatest in those during which general vegetation is most rapid, and less in those—the winter months—when it is torpid. For these and other such reasons the monthly distribution of rain influences the actual supply.

It is interesting to remark that the rainfall in New York greatly exceeds that of London. Here it is 47.62 inches, in London it is but 25 inches, and the mean for all England is estimated at 31.25 inches.

But these considerations of the amount of rainfall are only a portion of a far more general and most important problem, viz.:

Is the Climate of New York changing, or, more generally, is that of the Atlantic States undergoing Modification?

In this case, as in the preceding, there is a popular belief that clearing of land, drainage, and other agricultural operations, tend to produce such a result. Land that has been ploughed and exposes a dark surface to the sun, absorbs more heat, that is, becomes hotter, than land covered with forest-growth. It does not seem unreasonable, then, to suppose that, where thousands of square miles of surface have been submitted to such operations, the corresponding effect should be traceable, at least in the temperature of certain seasons of the year.

Moreover, there are some interesting facts which are matters of public observation and constant remark. Thus, as every one knows, in the city of New York itself, there are no longer the deep snows which characterized the winter seasons years ago. The large sleighs, often drawn by very many horses, used in those times as the public conveyances, have altogether disappeared from the streets. It would seem, therefore, that the winters have become milder. In like manner, though in support of this conclusion we have less palpable evidence, there is a very general opinion that the intolerable and long-continued heats, which formerly made the summer months almost unbearable, have greatly moderated, and, that, though the thermometer may occasionally rise as high as it formerly did, the continuance of the hot weather is shorter.

This popular opinion of change of climate through agricultural operations is far from being restricted to America. In Western Europe there is a belief that a great amelioration has taken place in all the Baltic countries since the time of the Roman domination.

In many instances these popular impressions are contradicted by well-ascertained facts. Thus, as respects the Baltic, there are records of the time of the breaking of the ice in some of the great rivers, such as the Dwina and Neva, for several centuries. These show that, during the last 300 years, the variation amounts but to a fraction of a single day.

Such fragments as have been preserved of the observations of the first discoverers of North America—the Icelandic voyagers—have been supposed to prove a change in the climate of New England during the last 800 years, it being affirmed that the vine formerly flourished in regions where it cannot now exist. One of the first papers communicated to the American Philosophical Society, in Philadelphia, was by Dr. Williamson, offering proof that, during the previous 40 or 50 years, a very great climate change had taken place; he attributed it to cultivation. Soon afterward, Dr. Williams, of Harvard University, offered evidence that the climate of Boston had changed 10° or 12° in about 160 years. A close examination of the evidence by more recent authorities has, however, shaken these conclusions. Thus, as regards the Icelandic voyages, it is shown that the description they give of the forest-growth of New England is the same that might be given now. Humboldt, in his "Views of Nature," comes to the conclusion that there has not been any change in the climate of the United States since its first colonial settlement, and in this, Noah Webster, Forry, and other American writers agree.

It is evident, however, that in a rapidly-growing city there are several local causes which may be assigned as giving origin to an increase of temperature. The quantity of fuel burnt increases with increased population and with the number of houses, and this must exert a perceptible effect in ameliorating the rigor of winter. Moreover, on sunshiny days, the reflection and radiation of the sun's warmth from the vertical sides of the houses must tend in no inconsiderable degree to raise the temperature locally, and aid in producing a thaw. The facts observed in a city are hence not a complete guide in the discussion of general climate changes.

If our climate be gradually changing, if the heat of summer is becoming less excessive, and the cold of winter more moderate, there are impending over us modifications in our social habits, and in many of our business occupations. Not only is the settlement of this question interesting in a meteorological or scientific point of view—the sanitary, engineering, manufacturing, mercantile, and agricultural consequences are also of the utmost importance.

Impressed with these considerations, I was therefore led to extend

my researches from the rainfall question to this more general problem; and, with the intention of not being misled by local observations made in the city itself, which, as we have just remarked, are not altogether to be trusted, I have resorted to data of a more general topographical kind, such, for instance, as the times of closing and opening of the Hudson River. Also, with a view of extending the conclusions, whatever they might prove to be, to the Atlantic coast generally, I have used such published records of the meteorology of Philadelphia, Boston, and Charleston, as I could find access to. These reach from 1738, with certain breaks, up to the present time.

TABLE SHOWING THE NUMBER OF DAYS THAT THE HUDSON RIVER HAS BEEN CLOSED BY ICE.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Years.	Days closed.	Years.	Days closed.	Years.	Days closed.	Years.	Days closed.	Years.	Days closed.
1817–18	108	1827–28	75	1837–38	94	1847–48	89	1857–58	92
1818–19	110	1828–29	100	1838–39	116	1848–49	82	1858–59	85
1819–20	102	1829–30	63	1839–40	65	1849–50	73	1859–60	85
1820–21	128	1830–31	82	1840–41	109	1850–51	69	1860–61	80
1821–22	92	1831–32	111	1841–42	47	1851–52	105	1861–62	100
1822–23	90	1832–33	80	1842–43	186	1852–53	91	1862–63	109
1823–24	78	1833–34	73	1843–44	95	1853–54	85	1863–64	82
1824–25	60	1834–35	100	1044–45	74	1854–55	108	1864–65	94
1825–26	75	1835–36	125	1845–46	100	1855–56	111	1865–66	90
1826–27	86	1836–37	111	1846–47	112	1856–57	98	1866–67	103
Mean of 10 y'rs	92 days.		92 days.		94 days.		90 days.		91 days.

The data connected with the Hudson River have been derived from the Annual Reports of the Regents of the University; those of temperature for the locality of New York itself, from the observations taken at Fort Columbus, and by Prof. Morris, for the Smithsonian Institution. The remainder are from the records of this observatory. In the case of other Atlantic cities, the data are chiefly derived from the reports of the United States Army officers to the Secretary of War.

It appears from this that, from 1816 to the present time, we have an unbroken register. Taking 1817 as our starting-point, we have to 1868 five periods of ten years each. The number of days during which the river was closed in each of these five periods is: For the first, 92 days; second, 92; third, 94; fourth, 90; fifth, 91.

The third period gives a greater number of days than any of the others; the general mean is about 91 days.

The conclusion at which we arrive from the evidence thus furnished by the Hudson River is, that during 50 years, that is to say, the whole period of trustworthy records, there has been no important change in the number of days that the river has remained frozen. In this respect the conclusion is the same as that which we have seen in the case of the Baltic rivers for a period of 300 years.

The evidence thus furnished from the closure of a river by ice differs from that of thermometric observations. The latter give merely the intensity of heat at the special moment, and in the special

locality at which the observation is made. The former represents the quantity of heat over a long line, including many localities. It is, therefore, the better form, and furnishes more trustworthy results.

Turning now to the records of the city of New York, as obtained from the sources above specified, we find they are continuous from 1821 to the present time. It would extend this report unduly were we to enter on an examination of each of these years respectively. Making a selection, then, let us compare the following groups of five years—first, from 1821 to 1827; second, from 1831 to 1837; third, from 1841 to 1847; fourth, from 1866 to 1872. It will be understood that the months selected are January, February, and March.

TABLE, SHOWING THE MEAN TEMPERATURE IN NEW YORK, FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Years.	Temperature.	Years.	Temperature.	Years.	Temperature.	Years.	Temperature
1822	32.71	1832	33.25	1842	38.81	1867	30.94
1823	30.96	1833	33.95	1843	30.81	1868	29.46
1824	34.78	1834	35.04	1844	31.43	1869	34.77
1825	36.36	1835	30.72	1845	36.36	1870	34.27
1826	32.62	1836	27.18	1846	32.69	1871	34.22
Mean for 5 y's.	33.48		32.02		34.02		32.73

The mean for January, February, and March, for thirty-three years, is 32.90 degrees. The mean for the above selection is 33.06 degrees.

The evidence thus derived from thermometric observations corroborates that derived from the freezing of the river, and undeniably leads to the conclusion that, if there has been any change in the winter climate of New York, it cannot be demonstrated by the extant thermometrical records of the last fifty years. This, therefore, adds weight to Humboldt's conclusion that there has been no sensible change in the Atlantic States since the time of their first settlement.

Let us next see what is the evidence afforded by an examination of the Philadelphia records. As in the preceding case, a discussion of all these would be too lengthy. They go as far back as 1748, but present, however, a broken series. Selecting from this, here and there, periods of five years, we may thus group them: first, from 1766 to 1772; second, from 1797 to 1803; third, from 1821 to 1827; fourth, from 1831 to 1837; fifth, from 1851 to 1857.

TABLE, SHOWING THE MEAN TEMPERATURE OF PHILADELPHIA, FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.
1767	35.06	1798	36.20	1822	33.40	1832	37.66	1852	34.10
1768	37.33	1799	35.13	1823	32.53	1833	37.33	1853	37.33
1769	35.66	1800	33.96	1824	35.86	1834	38.50	1854	36.56
1770	35.50	1801	36.70	1825	37.96	1835	33.33	1855	34.00
1771	35.33	1802	39.20	1826	36.33	1836	27.96	1856	27.66
Mean for 5 years.	35.37		36.23		35.11		34.95		34.06

The mean for January, February, and March, for fifty-six years, is 35.56 degrees. The mean for the above selection is 35.23 degrees.

From this, it would seem that the mean temperature of the first three months of the year at Philadelphia is 2.66 degrees above that of New York, and that the same conclusion arrived at in the preceding instances reappears in this, viz., that there has been no change in the winter climate.

The Boston records reach back to 1780. Taking the same periods as in the preceding instances, as far as these records will permit, they are—first, 1797 to 1803; second, 1821 to 1827; third, 1831 to 1837; fourth, 1850 to 1856. It is to be remarked that these observations are not all from the same station.

TABLE, SHOWING THE MEAN TEMPERATURE OF BOSTON FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temp'rature
1798	29.83	1822	29.26	1832	31.00	1851	30.53
1799	27.33	1823	27.63	1833	29.86	1852	27.03
1800	29.80	1824	31.60	1834	32.16	1853	30.26
1801	31.36	1825	33.16	1835	28.50	1854	26.46
1802	32.86	1826	31.26	1836	26.53	1855	26.96
Mean for 5 y'rs.	30.23		30.58		29.61		28.25

The mean for January, February, and March, for eighty-six years, is 29.63 degrees. The mean for the above selection is 29.66 degrees.

The mean temperature for the first three months of the year at Boston is 3.27 degrees lower than that of New York. These records give no substantial reason for supposing that, during the period of time to which they refer, there has been any sensible change in the winter climate of that locality.

In like manner, making a selection from the Charleston records, first, from 1749 to 1755; second, from 1754 to 1760; third, from 1822 to 1829; fourth, from 1830 to 1836; fifth, from 1849 to 1855—which date from 1738.

TABLE, SHOWING THE MEAN TEMPERATURE OF CHARLESTON FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.
1750	51.00	1755	51.66	1823	49.56	1831	51.26	1850	53.93
1751	54.33	1756	59.00	1824	54.06	1832	54.66	1851	56.26
1752	55.33	1757	58.33	1825	54.33	1833	55.20	1852	52.13
1753	57.00	1758	52.00	1827	55.73	1834	55.10	1853	52.20
1754	59.33	1759	48.66	1828	63.40	1835	46.20	1854	52.20
Mean for 5 years.	55.39		52.93		55.51		52.48		53.34

In this series, again, unfortunately the observations are from different stations. They exhibit greater divergences than any of the preceding cases; but notwithstanding that, so far from invalidating,

they strongly confirm the conclusion arrived at in those cases. Thus the mean of the first series is substantially the same as that of the third, being 55.39 and 55.51 respectively, though there is between them an interval of seventy-three years. The mean of the second is substantially the same as that of the fourth, being 52.93 degrees and 52.48 respectively, their interval being seventy-six years; and it may be especially remarked that the mean of the fifth series is very nearly the mean of all the other four, theirs being 54.07, and its 53.34 degrees.

Thus, again, we reach the same conclusion in the case of the city of Charleston that we arrived at in the case of New York, Philadelphia, and Boston, that the winter climate has not undergone any change.

The general conclusion which this examination seems to warrant, both as regards rainfall and winter climate, is this, that there has been no change in the lapse of many years. None can be substantiated as having occurred within a century. This proves that surface changes through agriculture, drainage, etc., give rise to no appreciable meteorological effect, and that the public opinion which asserts such an influence is altogether erroneous.

Only recently have precise and correct views been entertained of the progress of atmospheric changes. It is now known that cloudy weather, or rains, or fluctuations of the barometer and of the thermometer, are not of restricted or local origin, but that they have a progress in a determinate direction, often of thousands of miles. This fact is at the basis of the duties in which the Storm-Signal Corps is so ably engaged. In many parts of the United States there are prairie or treeless regions several hundreds of square miles in extent, yet these are not rainless because they are treeless; clouds drop water upon them to the same amount that they do on the neighboring wooded regions. Considerations such as these may satisfy us that the surface modifications which the Atlantic States have undergone, since their first settlement, have produced no meteorological effect, and that the rainfall and winter probably remain the same that they were many centuries ago.

I have restricted myself, in the foregoing climate examinations, to the winter season, and have said nothing as regards the summer. Had I done otherwise, it would have extended this report to an inconvenient length. Perhaps, however, what has here been substantiated, as to the permanency in the cold of the winter, will be held as affording strong presumptive evidence of a like permanency in the heats of summer, and that in these respects there is a mean degree which is maintained through indefinitely long periods of time.

While such is our final conclusion, we must bear in mind that these mean or average results exhibit only one phase of the problem. They do not show the fact that there are brief cycles of heat and cold, of moisture and dryness, following each other under the operation of

some unknown law, a law perhaps not of a meteorological but of an astronomical origin.

We should remember, however, the imperfections and probable errors of the old tables. In former times due care was not taken in the construction and verification of the thermometers. Making every allowance for this, we may perhaps admit that the conclusion at which we have arrived cannot be very far from the truth.

AS REGARDS SPIDERS.

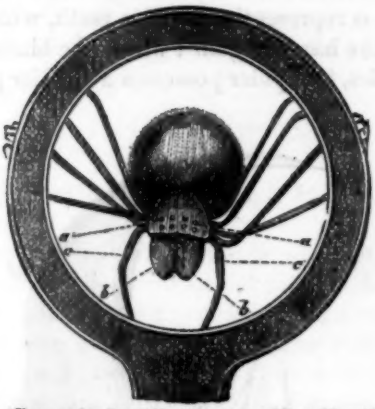
"WHAT can there be interesting in that commonplace, repulsive little creature, which infests our houses, annoys us by its presence, and shocks our sense of decency with its filthy webs—in that cruel little monster, whose whole life is employed in weaving snares to entrap unwary flies; lying in wait for them in dark, damp corners of crevices, murdering them remorselessly when they are caught in its toils, and then sucking their life's-blood? The house-spider, indeed! Why, we sweep it from the very face of Nature wherever we find it, together with its chamber of horrors; and it must indeed be some strong temptation that would induce one to defile one's hands by contact with a creature the very idea of which suffices to inspire terror and disgust."

It is true that spiders are not very lovable creatures, but this is a prejudiced statement. Spiders are only repulsive as long as we are ignorant of them. If we will but stop to observe their wonderful structure and their ingenious ways, we shall quickly get rid of these foolish notions, and find that the creature will richly repay us for the time and pains of studying it. Spiders have a great deal of character, and, although very savage, they have also much in common with the vaunted heads of creation. Let us consider some of their peculiarities.

Spiders were formerly classed as insects, and they are commonly so regarded still, but this is an error. Insects have but six legs, while spiders have eight; there is a division in insects between the head and the trunk, but spiders have no separate head, the head and thorax being fused together, under the name of *cephalothorax*. In many kinds, body, thorax, and abdomen, are so closely merged together that their parts cannot be traced. Again, insects undergo metamorphoses or transformations in their growth, while spiders do not. They belong to a group which includes mites and scorpions, and is named the *Arachnida*. There are multitudes of different kinds, and they vary in dimensions from the size of a grain of sand to several inches in diameter. Some spiders are met with in all parts of the world, and some are limited to special localities; some live in the fields, and others on the water; some dwell habitually in houses, and others are driven in by

cold weather; some inhabit the cellar, and others establish themselves in the corners of rooms, the angles of windows, openings in the woodwork, or chinks in the walls, and each has its special adaptations and modes of life.

Fig. 1.



The Female House-Spider (*Tegenaria domestica*), as seen with a Magnifier.—*a a*, Eyes; *b b*, Mandibles; *c c*, Maxillary Palpi.

Fig. 1 represents a small house-spider as seen under a magnifying-glass. It has eight eyes, simple in structure, and incapable of motion, but disposed in two rows on the top of the head, so that they enable the creature to espy its prey, from whatever quarter it may approach. Fig. 2 is this part of the animal represented still more highly magnified.

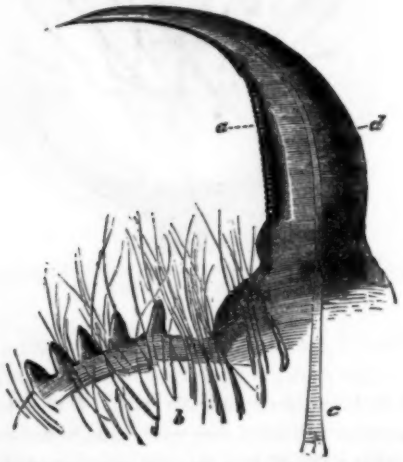
Fig. 2.

Enlarged View of Anterior Portion of Cephalothorax, bearing the Eight Eyes, and Hairs.—*a*, one of the Hairs magnified.

Spiders, being carnivorous, must make other creatures their prey, and they are very effectually provided with the means of doing so. No other animal is so terribly armed. Below the eyes (Fig. 1, *b b*) you perceive the large basal joints of the jaws, or mandibles as they are termed, with which they do their small work of butchery. Fig. 3 shows the appearance of this deadly instrument greatly magnified. "Picture to yourself a pair of huge, sharp-pointed jack-knives with extremely broad handles, the blades being so opposed to one another, that, when they are forcibly driven into an object, their pointed extrem-

ities encounter each other in the centre. Then conceive these knives to have the edges of their blades serrated with a row of fine teeth commencing near the haft, and on the handle itself five large, pointed teeth, shaped like the head of a lance, and upon which the saw-like blade can be brought to work to and fro." The large claw or horn (Fig. 3) answers to the blade, *a* representing its fine teeth, while *b* shows the five lance-like teeth in the handle against which the blade works. But, besides these mandibles, the spider possesses a smaller pair of jaws, called

FIG. 3.



Termination of the Jaw, or Mandible.—*a*, Row of Teeth on the Claw; *b*, Basal Joint of Mandible, showing the Five Large Teeth; *c*, Commencement of Poison-sac; *d*, Course of the Poison-duct. The last two are only visible when the mandible has been carefully bleached with chlorine.

the "maxillæ," which also have finely-toothed edges like deeply-cut rasps that most probably operate one against the other, to enlarge the wound made by the mandibles. This looks formidable enough, but it is not the worst. Nature has equipped the spider for very thorough work. This combination of dirks and saws is poisoned. At the basal joints of the mandibles there is a receptacle filled with a subtle venom which is conveyed through a tube (Fig. 3, *d*) to the pointed extremity of the blade. The moment this pierces the body of the prey, the poison is emitted, and, entering the wound, renders it fatal, probably at the same time benumbing the sensibility of the victim. The injected poison is nearly colorless, and possesses most of the properties that exist in the venom of the rattlesnake or the viper. The bite of a large spider on the back of the hand has been known to swell the whole arm, so that it was hardly recognizable as belonging to the human figure.

There is a famous spider called the *tarantula*, from the town of Tarentum, in Italy, where it is plentiful. It is believed by the people of that region that the bite of the tarantula produces the most ex-

traordinary effects—a silent melancholy, and convulsive movements, which can only be cured by music, while a certain tune is needful in each particular case. No doubt an epidemic nervous disease spread among persons of both sexes in this community, but it was a kind of contagious hysteria, that had nothing to do with the tarantula. That

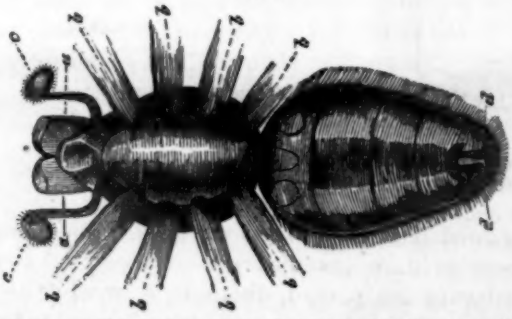
Fig. 4.

Edge of Maxilla, greatly enlarged, showing Teeth and Hairs.

this malady was cured by music, and consequent dancing, is very probable. The patient having indulged in long and continuous exercise, producing violent perspiration, became exhausted, fell asleep, and awoke cured.

The legs of the spider are admirably adapted to its peculiar mode

Fig. 5.

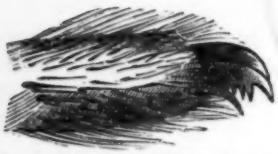


View of Under Surface of *Male* Spider, with the First Joints of the Legs.—*a a*, Mandibles; *b b*, Legs; *c c*, Maxillary Palpi; *d d*, Spinnerets.

of life. Fig. 5 represents the under surface of its body. Its eight legs are disposed in an oval upon the cephalothorax, and are long and slender, each having seven joints. They are suited for firmly grasping

its prey, and, when stretched out, while the creature is watching or moving, they cause the weight of the body to be distributed over a large surface of the fragile web. All this preparation for war is not thrown away, as spiders are plucky and desperate fighters. Although consummate strategists, and availing themselves to the utmost of cunning snares, they are ever ready for an attack, and fight ferociously. Their muscular force is very great, and some of them are so tenacious

Fig. 6.



Terminal Point of the Spider's Foot, showing the Hooked Comb.

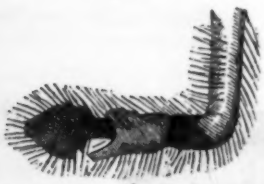
Fig. 7.

One of the Combs, highly magnified.

that it is difficult to make them let go their hold of the enemy that has been seized. Of the great crab-spider it is said that the obstinacy and bitterness which it exhibits in combat cease only with its life. Some of them have been seen, which, though pierced twenty times through and through, still continued to assail their adversaries without showing the least desire of escaping them by flight.

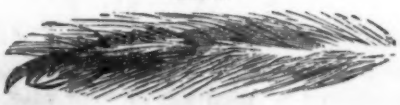
But let us proceed with the animal's structure. The long, many-jointed legs are terminated with a beautiful apparatus resembling a

Fig. 8.



Last Joint of one of the Maxillary Palpi of Male Spider.

Fig. 9.



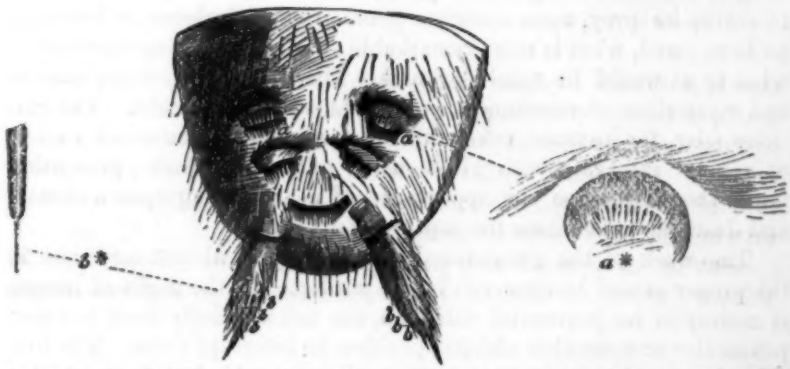
The same in the Female.

comb, with a pointed hook at the extremity. These instruments are not only of service in its encounters with enemies, but they are skilfully constructed to grasp, card, disentangle, or wind its threads with the utmost facility. Nothing comparable to it for this purpose can be found among all the contrivances of our factories. Again, glancing at Fig. 5, we notice, on either side of the head, what might be mistaken for a fifth pair of shorter legs: these are the *maxillary palpi*, which probably correspond partially to the feelers or antennæ of insects. They differ in the male and female, and the club-shaped palpi are said

to serve a most remarkable physiological end in connection with generation. The palpi of the male are furnished with several hooks, and a kind of cup (Fig. 8), while those of the female taper to a point, and are armed at the extremity with a toothed comb, like those at the end of the feet, and with several long, sword-shaped hairs.

But if, at the anterior extremity of the spider, we see in miniature the most perfect enginery of destruction, at its posterior extremity there is an equally marvellous device for the work of construction. If you direct your lens to the abdominal segment, you will observe what is represented in Fig. 10. The projections there seen are called *spinnerets*, and are contrivances for producing the web. One pair is prominent, the remaining two pairs having the appearance of circlets (Fig. 10, *a*), and they are all studded over with rows of little microscopic tubes (Fig. 10, *b b*). From these minute tubes there exudes a glutinous substance prepared in the spider's body, which solidifies into

FIG. 10.



Posterior Portion of Spider's Body, showing the Six Spinnerets.—*a*, Shorter Spinnerets, with Circlets of Tubes; *a**, the same magnified; *b b b*, Spinning-tubes on Long Spinnerets; *b**, Single Tube magnified.

a fine, strong filament as soon as it is exposed to the air. The microscope has proved that every one of these almost invisible fibres is composed of hundreds of finer ones, just as a ship's cable is formed of minute hempen fibres, while the main strand is spun far more rapidly than the eye can follow the process. The strength thus secured is very great, and the line is not only strong but elastic, like an India-rubber thread. Leuwenhoek, the renowned microscopist, who studied this subject carefully, made some extraordinary statements in regard to the minuteness of these threads. Some spiders, he says, that are not larger than a grain of sand, spin complex cords of which it would take millions to equal in thickness one of the hairs of his beard. If we ask why the mechanism was not simplified so that the animal should pay out only a single line, the obvious reply is that the multitude of finer filaments were necessary for quick drying and the firmest

cohesion. It is a remarkable fact that the spinnerets are under the prompt control of the spider's will, so that, in dropping from a height by the rapidly-forming line, the descent can be instantaneously stopped at any point. It is equally curious that, in ascending the line, a spider winds up the superfluous cord into a ball, and has a special claw or comb inserted between the others for the purpose.

Some kinds of spiders take to ballooning or migrating from place to place through the air. For this purpose they spin those long, loose and amazingly attenuous threads called *gossamer*, which exert a buoyant influence by which the animal is enabled to commit itself to atmospheric currents and move from place to place, and by which it gains the partial advantage of wings.

In the construction of webs for the snaring of its prey, the resources of the spider are endless. Dr. Samuelson, from whose admirable monograph our illustrations are taken, says: "With wonderful rapidity and instinct, the spider employs these threads to weave its web, or wanders from place to place, often constructing a perfect net, to entrap its prey, upon accurate geometrical principles, in less than an hour; and, what is most remarkable of all, performing this task in what to us would be total darkness. There are many other curious and mysterious circumstances connected with these webs. The garden-spider, for instance, covers all the concentric filaments of its net, at regular intervals, with glutinous or adhesive globules, presenting under the microscope the appearance of pearls strung upon a thread, and destined to facilitate the capture of its prey."

The work of the geometrical spiders may at almost any time in the proper season be observed in the garden. As the flight of insects is mainly in an horizontal direction, the net is usually fixed in a perpendicular or somewhat oblique position to intercept them. The first thing is to enclose a space with strong lines as a kind of frame, within which the web is to be formed. It is immaterial what is the shape of this enclosed area, as the spider is aware that she can as well inscribe a circle in a triangle as in a square. But these outside lines must be strong, and so they are formed of several threads glued together and attached to various objects of support. Mr. Spence thus describes the subsequent construction: "Having completed the foundations of her snare, she proceeds to fill up the outline. Attaching a thread to one of the main lines, she walks along it, guiding it with one of her hind-feet that it may not touch in any part, and be prematurely glued, and crosses over to the opposite side, where, by applying her spinners, she firmly fixes it. To the middle of this diagonal thread, which is to form the centre of her net, she fixes a second, which, in like manner, she conveys and fastens to another part of the lines encircling the area. Her work now proceeds rapidly. During the preliminary operations she sometimes rests, as though her plan required meditation. But no sooner are the marginal lines of her net firmly stretched, and

two or three radii spun from its centre, than she continues her labor so quickly and unremittingly that the eye can scarcely follow her progress. The radii, to the number of about twenty, giving the net the appearance of a wheel, are speedily finished. She then proceeds to the centre, quickly turns herself round, and pulls each thread with her feet to ascertain its strength, breaking any one that seems defective and replacing it by another. Next, she glues immediately round the centre five or six small, concentric circles, close to each other, and then four or five larger ones, each separated by a space of half an inch or more. These last serve as a sort of temporary scaffolding to walk over, and to keep the radii properly stretched while she glues to them the concentric circles that are to remain, which she now proceeds to construct. Placing herself at the circumference, and fastening her thread to the end of one of the radii, she walks up that one toward the centre, to such a distance as to draw the thread from her body of a sufficient length to reach to the next; then stepping across, and conducting the thread with one of her hind-feet, she glues it with her spinners to the point in the adjoining radius to which it is to be fixed. This process she repeats until she has filled up nearly the whole space from the circumference to the centre with concentric circles, distant from each other about the sixth of an inch. Besides the main web, the spider sometimes carries up from its edges and surface a number of single threads, often to the height of many feet, joining and crossing each other in various directions. Across these lines, which may be compared to the tackling of a ship, flies seem unable to avoid directing their flight. The certain consequence is that, in striking against these ropes, they become slightly entangled, and, in their endeavors to disengage themselves, rarely escape being precipitated into the net spread underneath for their reception, where their doom is inevitable."

The weaving-spider that is found in houses having selected a suitable site, in the same way forms first the margin or selvage of her web. From these she draws other threads, the spaces between which she fills up by running from one to the other, and connecting them by new lines, until the gauze-like texture is formed. The spider seems to be aware that she is no beauty, and had better conceal herself; so she constructs a small silken apartment, completely hidden from view, in which she lies in wait for her victims. But as this is often at a distance from the net, and entirely out of sight of it, how is she to know when an insect is caught? To meet this emergency, she spins several threads from the edge of the net to that of her hole, which answers as a telegraph by its vibrations, and is a railroad over which she can pass to secure it.

In their vital physiology spiders are quite as wonderful as in their other characters. We have said that they do not undergo metamorphoses, like insects, but the common household spider, which we have

figured (*Tegenaria domestica*), changes its integument, or skin, nine times before arriving at maturity, once in the cocoon and eight times after quitting it. If they lose a leg it is quickly reproduced, and this may take place half a dozen times in succession. Mr. Wood says, indeed, that "the harvest-spider seems to set little store by its legs, and will throw off one or two of them on the slightest provocation. Indeed, it is not very easy to find a harvest-spider with all its limbs complete; and, if such a being should be captured, it is nearly certain to shed a leg or two during the process. It appears to be totally indifferent to legs, and will walk off quite briskly with only half its usual complement of limbs. I have even known this arachnid to be deprived of all its legs save one, and to edge itself along by this solitary member, in a manner sufficiently ludicrous. The cast legs contain much irritability, and, even after they have been severed from the body, continue to bend and straighten themselves for some little time." The household spider above referred to lives four years; and the female, after one impregnation, is capable of producing nine sets of prolific eggs in succession, more than two years elapsing before all are deposited.

Morally, the spider has a bad reputation, and is the subject of many vile epithets; but, when compared with its accusers, it presents by no means a bad case. The Arachnidian ethics are in many respects strikingly coincident with more ambitious systems. The spider practises the virtues of industry, patience, and perseverance, under difficulties. The female is an affectionate parent, and very fond of her young. About June the garden-spider makes up her little packet of eggs, and encloses them in a snow-white silken envelope, and carries it about with her wherever she goes. If it is forcibly removed, she remains on the spot, hunting in every direction, and evidently in great distress; and if the white ball be laid near her she soon spies it, darts at it almost fiercely, and carries it off. "When the time comes for the little spiders to make their appearance in the world, the mother tears open the envelope, and so aids her young to escape. As soon as they are fairly out of the egg, they transfer themselves to the body of their parent, where they cling in such numbers that she is hardly visible under her swarming brood. They remain with their mother through the winter, and in the following spring the bonds of mutual affection are loosened, and the young disperse to seek their own living." If the spider is a skilful hunter and an ingenious trapper, so are the heroes of many novels; but the animal has not yet been known to indulge its predaceous practices in the way of mere wanton sport. It is merciless and cruel, like inquisitors and tyrants, but does not perpetrate its cruelties on the ground of difference of opinions. It is moved by self-interest, the alleged basis of all political economy. The spider "must live, you know," and it is a maxim with it to "look out for number one;" while it has a high appreciation of the advantages of "corner lots," but in all this it is by no means singular. Besides, the

spider contributes its share to the general weal. What would this world come to, if the flies could have their own way in it without let or hindrance? Killing flies is a necessary and righteous thing, and, as it is jointly undertaken by men, women, and spiders, for purposes of common beneficence, each should have an aliquot share of the honor. The spider, as we have seen, is also courageous and soldierly. He is fond of war, and, having taken a position, is very apt to "fight it out on that line," or system of lines, till crowned with victory. But it invests war with no sentiment of "glory," does not dress it up with gilt and feathers, nor use its passions as political stock-in-trade. Sundry misanthropes have claimed for the spider a standard of virtue higher than the human, as witness the following effusion:

"Ingenious insect, but of ruthless mould,
Whose savage craft, as Nature taught, designs
A mazy web of death—the filmy lines
That form thy circling labyrinth enfold
Each thoughtless fly that wanders near thy hold,
Sad victim of thy guile; nor aught avail
His silken wings, nor coat of glossy mail,
Nor varying lines of azure, jet, or gold;
Yet though thus ill the fluttering captive fares,
Whom heedless of the fraud thy toils trepan;
Thy tyrant fang that slays the stranger, spares
The bloody brothers of thy cruel clan;
While *man* against his fellows spreads his snares,
Then most delighted when his prey is *man*."

This is tolerable poetry, but very poor science. Truth compels us to drag the spider down to the human level—it does kill its own kind. Had it not been for this habit, men would have long ago enslaved the spiders to the silk-business. It is again charged that the spider is a cannibal, and, having killed his fellow-citizens, proceeds to devour them. But here, again, the spider can claim no originality, and is but an humble imitator of the lords of creation. It has, moreover, been accused of practising murder under very delicate circumstances, when its mind should only be occupied with tender feelings. It is true that love and courtship in the Arachnidian world are apt to be tragical. These creatures are quite too literal in their construction of the phrases, "You will kill me with your coldness," "Love me or I die;" but, in a higher sphere, does not love often become a bloody business of suicide and murder? Yet to the honor of humanity be it said, spiders do one thing which our sort do not: they kill their lovers, and then eat them up on the spot. In many species the male is much smaller than the female, and with these courtship is perilous. The female of the garden-spider is a perfect Amazon, and, when she happens to object to the attentions of her intended spouse, he has to fly for his life; a feat which he generally performs by flinging himself like lightning out

of the web, and lowering himself quickly to the earth by his silken ladder.

We here reach the perplexing question of "female rights," but decline to pursue it. "The Poet at the Breakfast-Table" has just bravely taken it up from this point of view, recommending the reformatory ladies to organize "Arachnoid Associations," with "Spinsters and Spiders" for a motto, and we leave the subject trustingly in his hands.

MAN AS THE INTERPRETER OF NATURE.

By WILLIAM B. CARPENTER, LL. D., F. R. S.[1]

IT has been customary with successive occupants of this chair to open the proceedings of the meetings over which they respectively presided with a discourse on some aspect of Nature in her relation to man. But I am not aware that any one of them has taken up the other side of the inquiry—that which concerns man as the "Interpreter of Nature;" and I have therefore thought it not inappropriate to lead you to the consideration of the mental processes by which are formed those fundamental conceptions of matter and force, of cause and effect, of law and order, which furnish the basis of all scientific reasoning, and constitute the *Philosophia prima* of Bacon. There is a great deal of what I cannot but regard as fallacious and misleading philosophy—"oppositions of science, falsely so called"—abroad in the world at the present time. And I hope to satisfy you that those who set up their own conceptions of the orderly sequence which they discern in the phenomena of Nature as fixed and determinate laws, by which those phenomena not only are, but always have been, and always must be, invariably governed, are really guilty of the intellectual arrogance they condemn in the systems of the ancients, and place themselves in antagonism to those real philosophers by whose grasp and insight that order has been so far disclosed. For what love of the truth, as it is in Nature, was ever more conspicuous than that which Kepler displayed in his abandonment of each of the conceptions of the planetary system which his imagination had successively devised, so soon as it proved to be inconsistent with the facts disclosed by observation? In that almost admiring description of the way in which his enemy Mars, "whom he had left at home a despised captive," had "burst all the chains of the equations, and broke forth from the prisons of the tables," who does not recognize the justice of Schiller's

[1] Inaugural Address of Dr. Carpenter before the British Association for the Advancement of Science, at Brighton, England, August 14, 1872, upon assuming the chair as president of that body.

definition of the real philosopher—as one who always loves truth better than his system? And when at last he had gained the full assurance of a success so complete that (as he says) he thought he must be dreaming, or that he had been reasoning in a circle, who does not feel the almost sublimity of the self-abnegation with which, after attaining what was in his own estimation such a glorious reward of his life of toil, he abstains from claiming the applause of his contemporaries, but leaves his fame to after-ages in these noble words: "The book is written; to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited 6,000 years for an observer."

And when a yet greater than Kepler was bringing to its final issue that grandest of all scientific conceptions, long pondered over by his almost superhuman intellect—which linked together the Heavens and the Earth, in the *nexus* of a universal attraction, establishing the truth for whose utterance Galileo had been condemned, and giving to Kepler's Laws a significance of which their author had never dreamed—what was the meaning of that agitation which prevented the philosopher from completing his computation, and compelled him to hand it over to his friend? That it was not the thought of his own greatness, but the glimpse of the grand universal order thus revealed to his mental vision, which shook the soul of Newton to its foundations, we have the proof in that comparison in which he likened himself to a child picking up shells on the shore of the vast ocean of truth—a comparison which will be evidence to all time at once of his true philosophy and of his profound humility.

Though it is with the intellectual representation of Nature which we call science that we are primarily concerned, it will not be without its use to cast a glance in the first instance at the other two principal characters under which man acts as her interpreter—those, namely, of the artist and of the poet.

The artist serves as the interpreter of Nature, not when he works as the mere copyist, delineating that which he sees with his bodily eyes, and which we could see as well for ourselves, but when he endeavors to awaken within us the perception of those beauties and harmonies which his own trained sense has recognized, and thus impart to us the pleasure he has himself derived from their contemplation. As no two artists agree in the original constitution and acquired habits of their minds, all look at Nature with different (mental) eyes; so that, to each, Nature is what he individually sees in her.

The poet, again, serves as the interpreter of Nature, not so much when by skilful word-painting (whether in prose or verse) he calls up before our mental vision the picture of some actual or ideal scene, however beautiful, as when, by rendering into appropriate forms those deeper impressions made by the Nature around him on the moral and emotional part of his own nature, he transfers these impressions to the

corresponding part of ours. For it is the attribute of the true poet to penetrate the secret of those mysterious influences which we all unknowingly experience; and, having discovered this to himself, to bring others, by the power he thus wields, into the like sympathetic relation with Nature, evoking with skilful touch the varied response of the Soul's finest chords, heightening its joys, assuaging its griefs, and elevating its aspirations. While, then, the artist aims to picture what he sees in Nature, it is the object of the poet to represent what he feels in Nature; and to each true poet Nature is what he individually finds in her.

The philosopher's interpretation of Nature seems less individual than that of the artist or the poet, because it is based on facts which any one may verify, and is elaborated by reasoning processes of which all admit the validity. He looks at the universe as a vast book lying open before him, of which he has in the first place to learn the characters, then to master the language, and finally to apprehend the ideas which that language conveys. In that book there are many chapters, treating of different subjects; and, as life is too short for any one man to grasp the whole, the scientific interpretation of this book comes to be the work of many intellects, differing not merely in the range but also in the character of their powers. But while there are "diversities of gifts," there is "the same spirit." While each takes his special direction, the general method of study is the same for all. And it is a testimony alike to the truth of that method and to the unity of Nature that there is an ever-increasing tendency toward agreement among those who use it aright—temporary differences of interpretation being removed, sometimes by a more complete mastery of her language, sometimes by a better apprehension of her ideas—and lines of pursuit which had seemed entirely distinct or even widely divergent being found to lead at last to one common goal. And it is this agreement which gives rise to the general belief—in many, to the confident assurance—that the scientific interpretation of Nature represents her not merely as she seems but as she really is.

When, however, we carefully examine the foundation of that assurance, we find reason to distrust its security; for it can be shown to be no less true of the scientific conception of Nature than it is of the artistic or the poetic, that it is a representation framed by the mind itself out of the materials supplied by the impressions which external objects make upon the senses, so that, to each man of science, Nature is what he individually believes her to be. And that belief will rest on very different bases, and will have very unequal values, in different departments of science. Thus in what are commonly known as the "exact" sciences, of which astronomy may be taken as the type, the data afforded by precise methods of observation can be made the basis of reasoning, in every step of which the mathematician feels the fullest assurance of certainty; and the final deduction is justified

either by its conformity to known or ascertainable facts—as when Kepler determined the elliptic orbit of Mars; or by the fiulfilment of the predictions it has sanctioned—as in the occurrence of an eclipse or an occultation at the precise moment specified many years previously; or, still more emphatically, by the actual discovery of phenomena till then unrecognized—as when the perturbations of the planets, shown by Newton to be the necessary results of their mutual attraction, were proved by observation to have a real existence; or, as when the unknown disturber of Uranus was found in the place assigned to him by the computations of Adams and Le Verrier.

We are accustomed, and I think most rightly, to speak of these achievements as triumphs of the human intellect. But the very phrase implies that the work is done by mental agency, and the coincidence of its results with the facts of observation is far from proving the intellectual process to have been correct. For we learn, from the confessions of Kepler, that he was led to the discovery of the elliptic orbit of Mars by a series of happy accidents, which turned his erroneous guesses into the right direction; and to that of the passage of the radius vector over equal areas in equal times by the motion of a whirling force emanating from the sun, which we now regard as an entirely wrong conception of the cause of orbital revolution. It should always be remembered, moreover, that the Ptolemaic system of astronomy, with all its cumbrous ideal mechanism, did intellectually represent all that the astronomer, prior to the invention of the telescope, could see from his stand-point the earth, with an accuracy which was proved by the fulfilment of his anticipations. And in that last and most memorable prediction, which has given an imperishable fame to our two illustrious contemporaries, the inadequacy of the basis afforded by actual observation of the perturbations of Uranus required that it should be supplemented by an assumption of the probable distance of the disturbing planet beyond, which has been shown by subsequent observation to have been only an approximation to the truth.

Even in this most exact of sciences, therefore, we cannot proceed a step without translating the actual phenomena of Nature into intellectual representations of those phenomena, and it is because the Newtonian conception is not only the most simple, but is also, up to the extent of our present knowledge, universal in its conformity to the facts of observation, that we accept it as the only scheme of the universe yet promulgated which satisfies our intellectual requirements.

When, under the reign of the Ptolemaic system, any new inequality was discovered in the motion of a planet, a new wheel had to be added to the ideal mechanism—as Ptolemy said, "to save appearances." If it should prove, a century hence, that the motion of Neptune himself is disturbed by some other attraction than that exerted by the interior planets, we should confidently expect that not an ideal but a real cause for that disturbance will be found in the existence of

another planet beyond. But I trust that I have now made it evident to you that this confident expectation is not justified by any absolute necessity of Nature, but arises entirely out of our belief in her uniformity; and into the grounds of this and other primary beliefs, which serve as the foundation of all scientific reasoning, we shall presently inquire.

There is another class of cases, in which an equal certainty is generally claimed for conclusions that seem to flow immediately from observed facts, though really evolved by intellectual processes; the apparent simplicity and directness of those processes either causing them to be overlooked or veiling the assumptions on which they are based. Thus Mr. Lockyer speaks as confidently of the sun's chromosphere of incandescent hydrogen, and of the local outbursts which cause it to send forth projections tens of thousands of miles high, as if he had been able to capture a flask of this gas, and had generated water by causing it to unite with oxygen.

Yet this confidence is entirely based on the assumption that a certain line which is seen in the spectrum of a hydrogen-flame means hydrogen also when seen in the spectrum of the sun's chromosphere; and, high as is the probability of that assumption, it cannot be regarded as a demonstrated certainty, since it is by no means inconceivable that the same line might be produced by some other substance at present unknown. And so, when Dr. Huggins deduces, from the different relative positions of certain lines in the spectra of different stars, that these stars are moving from or toward us in space, his train of reasoning is based on the assumption that these lines have the same meaning—that is, that they represent the same elements—in every luminary. That assumption, like the preceding, may be regarded as possessing a sufficiently high probability to justify the reasoning based upon it; more especially since, by the other researches of that excellent observer, the same chemical elements have been detected as vapors in those filmy cloudlets which seem to be stars in an early stage of consolidation. But, when Frankland and Lockyer, seeing in the spectrum of the yellow solar prominences a certain bright line not identifiable with that of any known terrestrial flame, attribute this to an hypothetical new substance which they propose to call Helium, it is obvious that their assumption rests on a far less secure foundation, until it shall have received that verification which, in the case of Mr. Crooke's researches on Thallium, was afforded by the actual discovery of the new metal, the presence of which had been indicated to him by a line in the spectrum not attributable to any substance then known.

In a large number of other cases, moreover, our scientific interpretations are clearly matters of judgment; and this is eminently a personal act, the value of its results depending in each case upon the qualifications of the individual for arriving at a correct decision. The surest of such judgments are those dictated by what we term "com-

mon-sense," as to matters on which there seems no room for difference of opinion, because every sane person comes to the same conclusion, although he may be able to give no other reason for it than that it appears to him "self-evident." Thus, while philosophers have raised a thick cloud of dust in the discussion of the basis of our belief in the existence of a world external to ourselves—of the Non-Ego, as distinct from the Ego—and while every logician claims to have found some flaw in the proof advanced by every other, the common-sense of mankind has arrived at a decision that is practically worth all the arguments of all the philosophers who have fought again and again over this battle-ground. And I think it can be shown that the trustworthiness of this common-sense decision arises from its dependence, not on any one set of experiences, but upon our unconscious coördination of the whole aggregate of our experiences—not on the conclusiveness of any one train of reasoning, but on the convergence of all our lines of thought toward this one centre.

Now, this "common-sense," disciplined and enlarged by appropriate culture, becomes one of our most valuable instruments of scientific inquiry; affording in many instances the best, and sometimes the only, basis for a rational conclusion. Let us take as a typical case, in which no special knowledge is required, what we are accustomed to call the "flint implements" of the Abbeville and Amiens gravel-beds. No logical proof can be adduced that the peculiar shapes of these flints were given to them by human hands; but does any unprejudiced person now doubt it? The evidence of design, to which, after an examination of one or two such specimens, we should only be justified in attaching a probable value, derives an irresistible cogency from accumulation. On the other hand, the improbability that these flints acquired their peculiar shape by accident becomes to our minds greater and greater as more and more such specimens are found; until at last this hypothesis, although it cannot be directly disproved, is felt to be almost inconceivable, except by minds previously "possessed" by the "dominant idea" of the modern origin of man. And thus what was in the first instance a matter of discussion has now become one of those "self-evident" propositions which claim the unhesitating assent of all whose opinion on the subject is entitled to the least weight.

We proceed upward, however, from such questions as the common-sense of mankind generally is competent to decide, to those in which special knowledge is required to give value to the judgment; and thus the interpretation of Nature by the use of that faculty comes to be more and more individual; things being perfectly "self-evident" to men of special culture which ordinary men, or men whose training has lain in a different direction, do not apprehend as such. Of all departments of science, geology seems to me to be the one that most depends on this specially-trained "common-sense;" which brings as it were into one focus the light afforded by a great variety of studies—physi-

cal and chemical, geographical and biological—and throws it on the pages of that Great Stone Book on which the past history of our globe is recorded. And while Astronomy is of all sciences that which may be considered as most nearly representing Nature as she really is, Geology is that which most completely represents her as seen through the medium of the interpreting mind; the meaning of the phenomena that constitute its data being in almost every instance open to question, and the judgments passed upon the same facts being often different according to the qualifications of the several judges. No one who has even a general acquaintance with the history of this department of science can fail to see that the geology of each epoch has been the reflection of the minds by which its study was then directed; and that its true progress dates from the time when that "common-sense" method of interpretation came to be generally adopted which consists in seeking the explanation of past changes in the forces at present in operation, instead of invoking the aid of extraordinary and mysterious agencies, as the older geologists were wont to do whenever they wanted—like the Ptolemaic astronomers—"to save appearances." The whole tendency of the ever-widening range of modern geological inquiry has been to show how little reliance can be placed upon the so-called "laws" of stratigraphical and paleontological succession, and how much allowance has to be made for local conditions. So that, while the astronomer is constantly enabled to point to the fulfilment of his predictions as an evidence of the correctness of his method, the geologist is almost entirely destitute of any such means of verification. For the value of any prediction that he may hazard—as in regard to the existence or non-existence of coal in any given area—depends not only upon the truth of the general doctrines of geology in regard to the succession of stratified deposits, but still more upon the detailed knowledge which he may have acquired of the distribution of those deposits in the particular locality. Hence no reasonably-judging man would discredit either the general doctrines or the methods of geology, because the prediction proves untrue in such a case as that now about to be brought in this neighborhood to the trial of experience.

We have thus considered man's function as the scientific interpreter of Nature in two departments of natural knowledge, one of which affords an example of the strictest and the other of the freest method which man can employ in constructing his intellectual representation of the universe. And, as it would be found that in the study of all other departments the same methods are used either separately or in combination, we may pass at once to the other side of our inquiry—namely, the origin of those primary beliefs which constitute the groundwork of all scientific reasoning.

The whole fabric of geometry rests upon certain axioms which every one accepts as true, but of which it is necessary that the truth should be assumed, because they are incapable of demonstration. So,

too, the deliverances of our common-sense derive their trustworthiness from what we consider the "self-evidence" of the propositions affirmed. This inquiry brings us face to face with one of the great philosophical problems of our day, which has been discussed by logicians and metaphysicians of the very highest ability as leaders of opposing schools, with the one result of showing how much can be said on each side.

By the intuitionalists it is asserted that the tendency to form these primary beliefs is inborn in man, an original part of his mental organization; so that they grow up spontaneously in his mind as its faculties are gradually unfolded and developed, requiring no other experience for their geneses than that which suffices to call these faculties into exercise. But, by the advocates of the doctrine which regards experience as the basis of all our knowledge, it is maintained that the primary beliefs of each individual are nothing else than generalizations which he forms of such experiences as he has either himself acquired or has consciously learned from others, and they deny that there is any original or intuitive tendency to the formation of such beliefs, beyond that which consists in the power of retaining and generalizing experiences.

I have not introduced this subject with any idea of placing before you even a summary of the ingenious arguments by which these opposing doctrines have been respectively supported; nor should I have touched on the question at all, if I did not believe that a means of reconcilement between them can be found in the idea that the intellectual intuitions of any one generation are the embodied experiences of the previous race. For, as it appears to me, there has been a progressive improvement in the thinking power of man; every product of the culture which has preceded serving to prepare the soil for yet more abundant harvests in the future.

Now, as there can be no doubt of the hereditary transmission in man of acquired constitutional peculiarities, which manifest themselves alike in tendencies to bodily and to mental disease, so it seems equally certain that acquired mental habitudes often impress themselves on his organization, with sufficient force and permanence to occasion their transmission to the offspring as tendencies to similar modes of thought. And thus, while all admit that knowledge cannot thus descend from one generation to another, an increased aptitude for the acquirement, either of knowledge generally or of some particular kind of it, may be thus inherited. These tendencies and aptitudes will acquire additional strength, expansion, and permanence, in each new generation, from their habitual exercise upon the materials supplied by a continually-enlarged experience; and thus the acquired habitudes produced by the intellectual culture of ages will become "a second nature" to every one who inherits them.[1]

[1] I am glad to be able to append the following extract from a letter which Mr. John Mill, the great Master of the Experimental School, was good enough to write to me a few

We have an illustration of this progress in the fact of continual occurrence, that conceptions which prove inadmissible to the minds of one generation in consequence either of their want of intellectual power to apprehend them or of their preoccupation by other habits of thought, subsequently find a universal acceptance, and even come to be approved as "self-evident." Thus the first law of motion, divined by the genius of Newton, though opposed by many philosophers of his time as contrary to all experience, is now accepted by common consent, not merely as a legitimate inference from experiment, but as the expression of a necessary and universal truth; and the same axiomatic value is extended to the still more general doctrine that energy of any kind, whether manifested in the "molar" motion of masses, or consisting in the "molecular" motion of atoms, must continue under some form or other without abatement or decay; what all admit in regard to the indestructibility of matter being accepted as no less true of force—namely, that as *ex nihilo nil fit*, so *nil fit ad nihilum*.[1] But, it may be urged, the very conception of these and similar great truths is in itself a typical example of intuition. The men who divined and enunciated them stand out above their fellows, as possessed of a genius which could not only combine but create, of an insight which could clearly discern what reason could but dimly shadow forth. Granting this freely, I think it may be shown that the intuitions of individual genius are but specially-exalted forms of endowments which are the general property of the race at the time, and which have come to be so in virtue of its whole previous culture. Who, for example, could refuse to the marvellous aptitude for perceiving the relations of numbers, which displayed itself in the untutored boyhood of George Bidder and Zerah Colburn, the title of an intuitive gift? But who, on the other hand, can believe that a Bidder or a Colburn could suddenly arise in a race of savages who cannot count beyond five? Or, again, in the history of the very earliest years of Mozart, who can fail to recognize the dawn of that glorious genius, whose brilliant but brief

months since, with reference to the attempt I had made to place "Common-Sense" upon this basis (*Contemporary Review*, February, 1872): "When states of mind in no respect innate or instinctive have been frequently repeated, the mind acquires, as is proved by the power of Habit, a greatly-increased facility of passing into those states; and this increased facility must be owing to some change of a physical character in the organic action of the Brain. There is also considerable evidence that such acquired facilities of passing into certain modes of cerebral action can in many cases be transmitted, more or less completely, by inheritance. The limits of this power of transmission, and the conditions on which it depends, are a subject now fairly before the scientific world; and we shall doubtless in time know much more about them than we do now. But so far as my imperfect knowledge of the subject qualifies me to have an opinion, I take much the same view of it that you do, at least in principle."

[1] This is the form in which the doctrine now known as that of the "Conservation of Energy" was enunciated by Dr. Mayer, in the very remarkable Essay published by him in 1845, entitled "Die organische Bewegung in ihrem Zus ammenhange mit dem Stoff-

career left its imperishable impress on the art it enriched? But who would be bold enough to affirm that an infant Mozart could be born among a tribe whose only musical instrument is a tom-tom, whose only song is a monotonous chant?

Again, by tracing the gradual genesis of some of those ideas which we now accept as "self-evident"—such, for example, as that of the "Uniformity of Nature"—we are able to recognize them as the expressions of certain intellectual tendencies, which have progressively augmented in force in successive generations, and now manifest themselves as mental instincts that penetrate and direct our ordinary course of thought. Such instincts constitute a precious heritage, which has been transmitted to us with ever-increasing value through the long succession of preceding generations; and which it is for us to transmit to those who shall come after us, with all that further increase which our higher culture and wider range of knowledge can impart.

And now, having studied the working action of the human intellect in the scientific interpretation of Nature, we shall examine the general character of its products; and the first of these with which we shall deal is our conception of matter and of its relation to force.

The psychologist of the present day views matter entirely through the light of his own consciousness: his idea of matter in the abstract being that it is a "something" which has a permanent power of exciting sensations, his idea of any "property" of matter being the mental representation of some kind of sensory impression he has received from it; and his idea of any particular kind of matter being the representation of the whole aggregate of the sense-perceptions which its presence has called up in his mind. Thus, when I press my hand against this table, I recognize its unyieldingness through the conjoint medium of my sense of touch, my muscular sense, and my mental sense of effort, to which it will be convenient to give the general designation of the tactile sense; and I attribute to that table a hardness which resists the effort I make to press my hand into its substance, while I also recognize the fact that the force I have employed is not sufficient to move its mass. But I press my hand against a lump of dough, and, finding that its substance yields under my pressure, I call it soft. Or, again, I press my hand against this desk, and I find that, although I do not thereby change its form, I change its place; and so I get the tactile idea of motion. Again, by the impressions received through the same sensorial apparatus, when I lift this book in my hand, I am led to attach to it the notion of weight or ponderosity; and, by lifting different solids of about the same size, I am enabled, by the different degrees of exertion I find myself obliged to make in order to sustain them, to distinguish some of them as light, and others as heavy. Through the medium of another set of sense-perceptions, which some regard as belonging to a different category, we distinguish between bodies that

feel "hot" and those that feel "cold;" and in this manner we arrive at the notion of differences of temperature. And it is through the medium of our tactile sense, without any aid from vision, that we first gain the idea of solid form, or the three dimensions of space.

Again, by the extension of our tactile experiences, we acquire the notion of liquids, as forms of matter yielding readily to pressure, but possessing a sensible weight which may equal that of solids; and of air, whose resisting power is much slighter, and whose weight is so small that it can only be made sensible by artificial means. Thus, then, we arrive at the notions of resistance and of weight as properties common to all forms of matter; and, now that we have got rid of that idea of light and heat, electricity and magnetism, as "imponderable fluids," which used to vex our souls in our scientific childhood, and of which the popular term "electric fluid" is a "survival," we accept these properties as affording the practical distinction between the "material" and the "immaterial."

Turning, now, to that other great portal of sensation, the sight, through which we receive most of the messages sent to us from the universe around, we recognize the same truth. Thus it is agreed, alike by physicists and physiologists, that color does not exist as such in the object itself; which has merely the power of reflecting or transmitting a certain number of millions of undulations in a second; and these only produce that affection of our consciousness, which we call color, when they fall upon the retina of the living percipient. And if there be that defect, either in the retina or in the apparatus behind it, which we call "color-blindness" or Daltonism, some particular hues cannot be distinguished, or there may even be no power of distinguishing any color whatever. If we were all like Dalton, we should see no difference, except in form, between ripe cherries hanging on a tree and the green leaves around them; if we were all affected with the severest form of color-blindness, the fair face of Nature would be seen by us as in the *chiaro-scuro* of an engraving of one of Turner's landscapes, not as in the glowing hues of the wondrous picture itself. And, in regard to our visual conceptions, it may be stated with perfect certainty, as the result of very numerous observations made upon persons who have acquired sight for the first time, that these do not serve for the recognition even of those objects with which the individual had become most familiar through the touch until the two sets of sense-perceptions have been coördinated by experience.[1] When once this coördination has been effected, however, the composite perception of

[1] Thus, in a recently-recorded case in which sight was imparted by operation to a young woman who had been blind from birth, but who had, nevertheless, learned to work well with her needle, when the pair of scissors she had been accustomed to use was placed before her, though she described their shape, color, and glistening metallic character, she was utterly unable to recognize them as scissors until she put her finger on them, when she at once named them, laughing at her own stupidity (as she called it) in not having made them out before.

form, which we derive from the visual sense alone, is so complete that we seldom require to fall back upon the touch for any further information respecting that quality of the object. So, again, while it is from the coördination of the two dissimilar pictures formed by any solid or projecting object upon our two retinæ that (as Sir Charles Wheatstone's admirable investigations have shown) we ordinarily derive through the sight alone a correct notion of its solid form, there is adequate evidence that this notion also is a mental judgment based on the experience we have acquired in early infancy by the consentaneous exercise of the visual and tactile senses.

Take, again, the case of those wonderful instruments by which our visual range is extended almost into the infinity of space or into the infinity of minuteness. It is the mental, not the bodily, eye that takes cognizance of what the telescope and the microscope reveal to us. For, we should have no well-grounded confidence in their revelations as to the unknown, if we had not first acquired experience in distinguishing the true from the false by applying them to known objects; and every interpretation of what we see through their instrumentality is a mental judgment as to the probable form, size, and movement of bodies removed by either their distance or their minuteness from being cognosced by our sense of touch.

The case is still stronger in regard to that last addition to our scientific *armamentum* which promises to be not inferior in value either to the telescope or the microscope; for it may be truly said of the spectroscope that it has not merely extended the range of our vision, but has almost given us a new sense by enabling us to recognize distinctive properties in the chemical elements which were previously quite unknown. And who shall now say that we know all that is to be known as to any form of matter, or that the science of the fourth quarter of this century may not furnish us with as great an enlargement of our knowledge of its properties, and of our power of recognizing them, as that of its third has done?

But, it may be said, Is not this view of the material universe open to the imputation that it is "evolved out of the depths of our own consciousness"—a projection of our own intellect into what surrounds us—an ideal rather than a real world? If all we know of matter be an "intellectual conception," how are we to distinguish this from such as we form in our dreams, for these, as our Laureate no less happily than philosophically expresses it, are "true while they last." Here our "common-sense" comes to the rescue. We "awake, and behold it was a dream." Every healthy mind is conscious of the difference between his waking and his dreaming experiences, or, if he is now and then puzzled to answer the question, "Did this really happen or did I dream it?" the perplexity arises from the consciousness that it might have happened. And every healthy mind, finding its own experiences of its waking state not only self-consistent, but consistent with

the experiences of others, accepts them as the basis of his beliefs, in preference to even the most vivid recollections of his dreams.

The lunatic pauper, who regards himself as a king, the asylum in which he is confined as a palace of regal splendor, and his keepers as obsequious attendants, is so "possessed" by the conception framed by his disordered intellect that he does project it out of himself into his surroundings; his refusal to admit the corrective teaching of common-sense being the very essence of his malady. And there are not a few persons abroad in the world who equally resist the teachings of educated common-sense whenever they run counter to their own preconceptions, and who may be regarded as—in so far—affected with what I once heard Mr. Carlyle pithily characterize as a "diluted insanity."

It has been asserted over and over again of late years, by a class of men who claim to be the only true interpreters of Nature, that we know nothing but matter and the laws of matter, and that force is a mere fiction of the imagination. May it not be affirmed, on the other hand, that, while our notion of matter is a conception of the intellect, force is that of which we have the most direct—perhaps even the only direct—cognizance? As I have already shown you, the knowledge of resistance and of weight which we gain through our tactile sense is derived from our own perception of exertion; and in vision, as in hearing, it is the force with which the undulations strike the sensitive surface that affects our consciousness with sights or sounds. True it is that in our visual and auditory sensations we do not, as in our tactile, directly cognosce the force which produces them; but the Physicist has no difficulty in making sensible to us, indirectly, the undulations by which sound is propagated, and in proving to our intellect that the force concerned in the transmission of light is really enormous.

It seems strange that those who make the loudest appeal to experience as the basis of all knowledge, should thus disregard the most constant, the most fundamental, the most direct of all experiences; as to which the common-sense of mankind affords a guiding light much clearer than any that can be seen through the dust of philosophical discussion. For, as Sir John Herschel most truly remarked, the universal consciousness of mankind is as much in accord in regard to the existence of a real and intimate connection between cause and effect as it is in regard to the existence of an external world; and that consciousness arises to every one out of his own sense of personal exertion in the origination of changes by his individual agency.

Now, while fully accepting the logical definition of cause as the "antecedent or concurrence of antecedents on which the effect is invariably and unconditionally consequent," we can always single out one dynamical antecedent—the power which does the work—from the aggregate of material conditions under which that power may be distributed and applied. No doubt the term "cause" is very loosely

employed in popular phraseology; often (as Mr. Mill has shown) to designate the occurrence that immediately preceded the effect—as when it is said that the spark which falls into a barrel of gunpowder is the cause of its explosion, or that the slipping of a man's foot off the rung of a ladder is the cause of his fall. But even a very slightly-trained intelligence can distinguish the power which acts in each case from the conditions under which it acts. The force which produces the explosion is locked up, as it were, in the powder; and ignition merely liberates it by bringing about new chemical combinations. The fall of the man from the ladder is due to the gravity which was equally pulling him down while he rested on it; and the loss of support, either by the slipping of his foot or by the breaking of the rung, is merely that change in the material conditions which gives the power a new action.

Many of you have doubtless viewed with admiring interest that truly wonderful work of human design, the Walter printing-machine. You first examine it at rest; presently comes a man who simply pulls a handle toward him, and the whole inert mechanism becomes instinct with life—the blank paper, continuously rolling off the cylinder at one end, being delivered at the other, without any intermediate human agency, as large sheets of print, at the rate of 15,000 in an hour. Now, what is the cause of this most marvellous effect? Surely it lies essentially in the power or force which the pulling of the handle brings to bear on the machine from some extraneous source of power, which we in this instance know to be a steam-engine on the other side of the wall. This force it is, which, distributed through the various parts of the mechanism, really performs the action of which each is the instrument; they only supply the vehicle for its transmission and application. The man comes again, pushes the handle in the opposite direction, detaches the machine from the steam-engine, and the whole comes to a stand; and so it remains, like an inanimate corpse, until recalled to activity by the renewal of its moving power.

But, say the reasoners who deny that force is any thing else than a fiction of the imagination, the revolving shaft of the steam-engine is "matter in motion;" and, when the connection is established between that shaft and the one that drives the machine, the motion is communicated from the former to the latter, and thence distributed to the several parts of the mechanism. This account of the operation is just what an observer might give who had looked on with entire ignorance of every thing but what his eyes could see; the moment he puts his hand upon any part of the machinery and tries to stop its motion, he takes as direct cognizance, through his sense of the effort required to resist it, of the force which produces that motion as he does through his eye of the motion itself.

Now, since it is universally admitted that our notion of the external world would be not only incomplete, but erroneous, if our visual

perceptions were not supplemented by our tactile, so, as it seems to me, our interpretation of the phenomena of the Universe must be very inadequate if we do not mentally coördinate the idea of force with that of motion, and recognize it as the "efficient cause" of those phenomena—the "material conditions" constituting (to use the old scholastic term) only "their formal cause." And I lay the greater stress on this point, because the mechanical philosophy of the present day tends more and more to express itself in terms of motion rather than in terms of force—to become kinetics, instead of dynamics.

Thus, from whatever side we look at this question—whether the common-sense of mankind, the logical analysis of the relation between cause and effect, or the study of the working of our own intellects in the interpretation of Nature—we seem led to the same conclusion—that the notion of force is one of those elementary forms of thought with which we can no more dispense than we can with the notion of space or of succession. And I shall now, in the last place, endeavor to show you that it is the substitution of the dynamical for the mere phenomenal idea which gives their highest value to our conceptions of that order of Nature, which is worshipped as itself a god by the class of interpreters whose doctrine I call in question.

The most illustrative, as well as the most illustrious example of the difference between the mere generalization of phenomena and the dynamical conception that applies to them, is furnished by the contrast between the so-called laws of planetary motion discovered by the persevering ingenuity of Kepler, and the interpretation of that motion given us by the profound insight of Newton. Kepler's three laws were nothing more than comprehensive statements of certain groups of phenomena determined by observation. The first, that of the revolution of the planets in elliptical orbits, was based on the study of the observed places of Mars alone; it might or might not be true of the other planets; for, so far as Kepler knew, there was no reason why the orbits of some of them might not be the eccentric circles which he had first supposed that of Mars to be. So Kepler's second law of the passage of the radius vector over equal areas in equal times, so long as it was simply a generalization of facts in the case of that one planet, carried with it no reason for its applicability to other cases, except that which it might derive from his erroneous conception of a whirling force. And his third law was in like manner simply an expression of a certain harmonic relation which he had discovered between the times and the distances of the planets, having no more rational value than any other of his numerous hypotheses.

Now, the Newtonian "laws" are often spoken of as if they were merely higher generalizations in which Kepler's are included; to me they seem to possess an altogether different character. For, starting with the conception of two forces, one of them tending to produce continuous uniform motion in a straight line, the other tending to produce

a uniformly accelerated motion toward a fixed point, Newton's wonderful mastery of geometrical reasoning enabled him to show that, if these dynamical assumptions be granted, Kepler's phenomenal "laws," being a necessary consequence of them, must be universally true. And while that demonstration would have been alone sufficient to give him an imperishable renown, it was his still greater glory to divine that the fall of the moon toward the earth—that is, the deflection of her path from a tangential line to an ellipse—is a phenomenon of the same order as the fall of a stone to the ground; and thus to show the applicability to the entire universe of those simple dynamical conceptions which constitute the basis of the geometry of the "Principia."

Thus, then, while no "law" which is simply a generalization of phenomena can be considered as having any coercive action, we may assign that value to laws which express the universal conditions of the action of a force, the existence of which we learn from the testimony of our own consciousness. The assurance we feel, that the attraction of gravitation must act under all circumstances according to its one simple law, is of a very different order from that which we have in regard (for example) to the laws of chemical attraction, which are as yet only generalizations of phenomena. And yet, even in that strong assurance, we are required, by our examination of the basis on which it rests, to admit a reserve of the possibility of something different—a reserve which we may well believe that Newton himself must have entertained.

A most valuable lesson as to the allowance we ought to make for the unknown "possibilities of Nature" is taught us by an exceptional phenomenon so familiar that it does not attract the notice it has a right to claim. Next to the law of the universal attraction of masses of matter, there is none that has a wider range than that of the expansion of bodies by heat. Excluding water and one or two other substances, the fact of such expansion might be said to be invariable, and, as regards bodies whose gaseous condition is known, the law of expansion can be stated in a form no less simple and definite than the law of gravitation. Supposing those exceptions then to be unknown, the law would be universal in its range. But it comes to be discovered that water, while conforming to it in its expansion from 39½° upward to its boiling-point, as also, when it passes into steam, to the special law of expansion of vapors, is exceptional in its expansion also from 39½° downward to its freezing-point; and of this failure in the universality of the law no *rationale* can be given. Still more strange is it that by dissolving a little salt in water we should remove this exceptional peculiarity, for sea-water continues to contract from 39° downward to its freezing-point 12° or 14° lower, just as it does with reduction of temperature at higher ranges.

Thus, from our study of the mode in which we arrive at those conceptions of the orderly sequence observable in the phenomena of Na-

ture which we call "laws," we are led to the conclusion that they are human conceptions subject to human fallibility, and that they may or may not express the ideas of the Great Author of Nature. To set up these laws as self-acting, and as either excluding or rendering unnecessary the power which alone can give them effect, appears to me as arrogant as it is unphilosophical. To speak of any law as "regulating" or "governing" phenomena is only permissible on the assumption that the law is the expression of the *modus operandi* of a governing power. I was once in a great city which for two days was in the hands of a lawless mob. Magisterial authority was suspended by timidity and doubt; the force at its command was paralyzed by want of resolute direction. The "laws" were on the statute-book, but there was no power to enforce them. And so the powers of evil did their terrible work, and fire and rapine continued to destroy life and property without check, until new power came in, when the reign of law was restored.

And thus we are led to the culminating point of man's intellectual interpretation of Nature—his recognition of the unity of the power of which her phenomena are the diversified manifestations. Toward this point all scientific inquiry now tends. The convertibility of the physical forces, the correlation of these with the vital, and the intimacy of that *nexus* between mental and bodily activity which, explain it as we may, cannot be denied, all lead upward toward one and the same conclusion; and the pyramid of which the philosophical conclusion is the apex has its foundation in the primitive instincts of humanity.

By our own remote progenitors, as by the untutored savage of the present day, every change in which human agency was not apparent was referred to a particular animating intelligence. And thus they attributed not only the movements of the heavenly bodies, but all the phenomena of Nature, each to its own deity. These deities were invested with more than human power; but they were also supposed capable of human passions and subject to human capriciousness. As the uniformities of Nature came to be more distinctly recognized, some of these deities were invested with a dominant control, while others were supposed to be their subordinate ministers. A serene majesty was attributed to the greater gods who sit above the clouds; while their inferiors might "come down to earth in the likeness of men." With the growth of the scientific study of Nature, the conception of its harmony and unity gained ever-increasing strength. And so, among the most enlightened of the Greek and Roman philosophers, we find a distinct recognition of the idea of the unity of the directing mind from which the order of Nature proceeds; for they obviously believed that, as our modern poet has expressed it—

> "All are but parts of one stupendous whole,
> Whose body Nature is, and God the Soul."

The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the order of Nature, it has separated itself wholly from theology, whose function it is to seek after its cause. In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded, in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. But, when science, passing beyond its own limits, assumes to take the place of theology and sets up its own conception of the order of Nature as a sufficient account of its cause, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends.

For, while the deep-seated instincts of humanity and the profoundest researches of philosophy alike point to mind as the one and only source of power, it is the prerogative of science to demonstrate the unity of the power which is operating through the limitless extent and variety of the universe, and to trace its continuity through the vast series of ages that have been occupied in its evolution.

PHYSIOLOGICAL INFLUENCE OF CONDIMENTS.

By Prof. VOIT.

(ABSTRACT OF VOIT'S REPORT, BY ANDRÉ SANSON.)

BESIDES the elements of nutrition which we consume at every meal, there is also a number of other elements which serve to make the food savory and appetizing. These latter do not strictly come within the definition of nutritive substances, and are properly denominated condiments. Though not in themselves nutritious, the condiments are nevertheless necessary to nutrition. Their importance, however, as constituents of food, has not hitherto been duly appreciated. We must determine with exactitude the action both of the various elements of nutrition and of the condiments, and employ, to express this difference, well-defined terms, if we would avoid all confusion in treating the subject. Before we state what is the action of the salts and of the extractive elements of nutrition, as condiments, we must first consider the action of condiments in general. It is commonly supposed that they excite in the palate agreeable sensations, and so produce simply an excitation which, however, serves no useful purpose; and that, when once they enter into the blood, they bring about in it abnormal states and unnatural excitation. However, they are not regarded as hurtful.

Condiments act principally upon the nervous system. Some of them, for instance, excite the nerve termini of the mucous membrane of the digestive canal, whence the excitation or stimulus passes to cer tain centres in the intestine, or to more remote centres in the spinal cord, the brain, etc. Others of them, having been absorbed in the blood, reach the central organ of the nervous system, and act upon it. Passing beyond all these nerve-centres, their influence may extend farther, and may, through the intestinal canal, affect portions of the system which have no direct relation to digestion.

Bearing all this in mind, we perceive that the term *condiment* is commonly used in too restrictive a sense, being applied to but a few of the substances which act upon the system in the manner above indicated. There is no reason why we should give the name of condiments only to those substances which produce agreeable and useful stimulation in the nervous system, either by exciting the palate or by entering into the blood. The site of the excitation is immaterial, and cannot determine whether a substance is or is not properly a condiment. The first effects produced by sundry agents not commonly regarded as condiments—tea and coffee, for example—are at bottom the same as those produced by the condiments. As for those substances which produce their effects only when they have entered into the blood, and which have nothing to do with digestion, these have been regarded as condiments if they are absorbed by the intestinal canal, as caffeine; or by the nasal mucous membrane, as the nicotine of snuff. To be consistent, we must give the same name of condiment to sundry substances which are not at all *eaten*. This will readily be admitted with regard to the sense of smell, since many dishes, instead of pleasing by their flavor, please rather by their agreeable odor. The volatile elements of food, by gratifying the sense of smell, become true condiments. The same is to be said of other volatile elements which are not derived from articles of food, such as the fragrance of flowers, etc.

The excitation of the organs of taste or of smelling produces, in certain determinate portions of the brain, corresponding agreeable sensations. The process is essentially the same in the case of sensations of hearing or of seeing. Hence we might reckon among condiments the vibrations of the ether, and those of sound. However wide the difference between the pleasure we experience in the contemplation of a Madonna by Raffaelle, the hearing of one of Beethoven's symphonies, inhaling the fragrance of a rose, and tasting a savory fruit, still these have all something in common. External causes will always produce a movement in the nerves, and this will be transmitted to certain points of the central organ, where it will give rise to sensations; and thence again there may be transmitted to still other centres other nerve-influences, which will produce simultaneous action in other points.

The term *condiment*, as commonly used, is taken in too restricted

a sense in another point of view. An agent acting upon the mucous membrane of the mouth, stomach, or intestine, may produce in the nervous system important effects as regards digestion, and yet we may have no sensation of this either through taste or through smell, its parts not entering into communication with the central organ of sensation.

Having thus given a notion of what he understands by condiments, the author lays some stress upon the foregoing considerations, in order to show that a substance may be rigorously denominated a *condiment*, without exercising any agreeable effect upon the organs of taste. Still the chief condiments do undoubtedly produce this effect. A mixture of pure albumen, fat, starch, salts, and water, would suffice for alimentation, and yet it would be a satisfactory ration only in case of extreme want. In any other case we should regard it as unpalatable, and should refuse to partake of it. All alimentary substances, even those which come from the vegetable kingdom, are combined with substances which, though not nutritious, still have a flavor, and the former are not easily digested unless they first gratify the palate. Substances without flavor, or which are repulsive to the palate, are nauseating, and cause vomiting. There exists, therefore, a functional relation between the central organ of taste and the stomach. If the former acts upon the latter adversely, it may also act favorably upon it. In like manner, too, the central organ of taste is influenced by the stomach. Satiety deprives food, which once was agreeable to us, of its power of gratifying the palate.

Several condiments act upon the stomach, or on the intestine, after having first produced an agreeable sensation of taste. The excitation to which they give rise does not extend to the central organ, there to produce the same sensation. They are limited to the stomach and to the intestine, and serve to favor digestion and absorption. The gastric juice, we know, is not secreted continually, but only when there is something in the stomach. When the mucous membrane of that organ is excited by the contact of a quill, for instance, or of a glass rod, the gastric juice begins to flow, and the vessels of the mucous membrane become charged with blood. The presence of food produces the same effect. But there are other excitations which appear to act even more powerfully on the stomach. If we introduce a drop of alcohol or ether, or a solution of common salt, into the stomach of a living animal, the juice will flow from the glands, just as the same effect is produced by the thought of some savory dish. We may observe this when we offer a hungry dog a piece of meat. It is for this reason that we frequently add to our food substances strongly salted or aromatized, as, for instance, a caviare, or a glass of some spirituous liquor, such as sherry. The same effect may even be produced by the very sight of the label borne by such articles. When meat is roasted at a hot fire, it brings about this same result in the best and simplest manner; and most of

the flavors and pleasing odors of food have the same effect. Hence we see their importance as means of promoting digestion.

The extract of meat belongs to the class of condiments. It first gratifies the palate, and then produces important results in the stomach. This is not due to the nutritive salts it contains, nor to any special effect it produces on absorption or nutrition. If an animal gets for food only extract of meat, it will succumb more quickly than if no food at all were given, as was demonstrated by Kemmerich in the case of a dog. We may account for this either on the supposition that the salts accelerate the transformation of albumen, or that the potash of the extract acts injuriously on the heart. Therefore, when vessels, fortresses, armies, and hospitals, are supplied with this meat-extract, they obtain what we must regard as an excellent *condiment;* but that will not supply the place of a single grain of the nutritive elements; and in this regard it is analogous to table-salt, coffee, tobacco, etc. Nevertheless, we cannot question the beneficial effect of a good meat-broth upon the stomach, whether in health or in sickness. Especially does it produce a good effect in the case of convalescents whose stomach is in a chronic state of debility. They cannot retain common food, except it is given to them in the shape of broth. Just as the excitation of the mucous membrane of the mouth has an effect upon the stomach, so, probably, the stomach acts upon the intestine. Thus, for instance, soon after the stomach is filled, we find the pancreas addressing itself to its function.

There are some condiments the effects of which are not at first local. They act only after having been absorbed, and their action is then perceptible in the central nervous system. This is the case, for instance, with coffee, tea, tobacco, alcoholic drinks, etc., the general action of which is well known. It has been supposed that we have here an arrest of decomposition, an economy of nutritive material. In fact, we have only another mode of arrangement or of change in the inward phenomena. The amount of work of which a man is capable depends very much upon his momentary disposition. With equal nutritive transformations, and with equal production of living force, the man who undertakes a work under favorable moral conditions will perform it more easily than another who happens to be oppressed and weighed down by some affliction. A stroke of the whip causes a horse to surmount an obstacle, before which he would have stood still without that stimulus; and yet the latter does not communicate to him any force; it only induces him to exert the force he already possessed. It is thus that condiments act upon certain determinate parts of our nervous centre, and so enable us to attain our ends. We may regard as of similar nature to this the action of opium or of musk, under the influence of which a man, who before was perfectly powerless, appears to get new life, without any demonstrable elementary change having taken place in his body. The same is to be said

of the influence of alcohol, and of common salt, leaving out of the account their local action in the mouth and stomach.

Does the same hold good for extract of meat? None of the known organic elements of this extract have an action analogous to that of caffeine, nicotine, or alcohol. Still it is certain that the potash which it contains brings about results which are essentially general. It renders the nerves and the muscles more excitable, and produces an acceleration of the contractions of the heart. Kemmerich was at first disposed to attribute the exciting and quickening action of the extract to the potash which it contains; and he has shown that meat-extract, reduced to ashes, produces a fatal effect when administered in the same quantity which is fatal before it is so reduced. He has demonstrated that a dose of chloride of potassium, containing the same quantity of potash which is contained in a half-pound of meat, accelerates the beating of the heart in a healthy subject. Yet, notwithstanding this, we are not to overlook local action, and suppose with Kemmerich that the extract of meat might give place to a small quantity of potash, and still leave the food equally nutritious.

We might accordingly attribute to the extract of meat the same property which characterizes animal food, viz., the production of an extraordinary degree of energy and vigor. Here Voit observes that this property does not belong to the extractive elements, but rather to the albuminoid materials, the proportion of which contained in animal food exceeds that contained in vegetables, as compared with the non-nitrogenized elements. Indeed, if we feed a carnivorous animal on a small quantity of meat, with a large amount of fat and meat-extract, he loses his natural liveliness. The same theory holds good for man, when fed on vegetable diet and the extract of meat. His vigor is far less than when meat forms the basis of his food. But on the other hand, if we give to an herbivorous animal food rich in albuminoid principles, if, for instance, we give to a horse an abundance of oats, the result will be the same as when a carnivorous animal is given animal food.

The action of meat-extract on the animal economy is, therefore, simply that of a condiment. Liebig attributes to it no other action, though the matter has frequently been involved in confusion. This action is, however, very important and beneficial. It is also possessed by certain vegetable extracts. Thus soups of high flavor and very strengthening may be made with the extract of the tomato, which has an acid reaction.

The foregoing remarks give only a partial view of the important function of condiments in promoting nutrition. Neither man nor animals take their food without some condiment. The simplest food always possesses some quality which serves as its condiment. It is only in virtue of this that vegetables gratify the palate. Thus in fruits for example, there are acids, volatile oils, etc. Most of the con-

diments are derived from the vegetable kingdom. Every people has its own favorite condiment. Every one likes to find an agreeable flavor in his food, and we have it prepared in such a way as to acquire the peculiar flavor we like. For the same reason we like variety in articles of food. In time the persistent impression of one flavor produces disgust, and so what once was savory now becomes unpleasant. Therefore, if one were to be confined for a considerable time to a fixed diet, he would not thrive upon it, no matter how rich it might be in the elements of nutrition, for the reason that the influence of the condiment would be nullified.

There are, besides, many other influences which act upon digestion, but of which we commonly think little. In taking food we strive to combine various enjoyments, so that many organic manifestations may conspire together to promote the action of the digestive apparatus. The organ of smell is situated near that of taste. Those dishes which contain volatile elements are rather smelt than tasted. We give an agreeable smell to some articles of food by adding to them others which are fragrant. Dishes to which we are unaccustomed we partake of with repugnance, and generally they cannot be retained. We also give to dishes agreeable forms, and set them on the table with some regard to their appearance, and this makes them "appetizing." If they are served up without any regard to such considerations, they excite only repugnance. The frame of mind in which one may happen to be is also a matter of importance. If our thoughts are preëngaged, or if we are in trouble, we have no desire for food. The presence of a sprightly child, or of friends, at the board, is a true condiment. How different is the process of digestion when a meal is taken in full view of a pleasing landscape, or behind the bars of a prison-cell!

We are continually exposed to a multitude of excitations or influences from without. These give us sensations which are not alone agreeable, but also useful and necessary. Thus alone can we *live*. Though by many persons the limits of moderation are overstepped in seeking this kind of gratification, and they are made thus hurtful, it does not thence follow that they are to be avoided. If some men make an abusive use of food, we are not therefore to conclude that the proper course is to abstain altogether from food, any more than we should conclude, from the fact that the feasts of Lucullus are every day repeated, that therefore, instead of palatable food, whether animal or vegetable, one should eat only a tasteless mixture of albuminates, fat, starch, etc. There is danger of excess in every action we perform, but a man of sense will always respect the law which determines for him what is beneficial and what hurtful.—*Revue Scientifique.*

ENGLISH AGAINST THE CLASSICS.

BY A SCOTCH GRADUATE.[1]

NOT long ago, the Lord Rector of the University of Aberdeen submitted to the University Court a scheme for reducing the value of Latin composition. In a lecture recently given at Edinburgh upon education, Prof. Jowett condemned the existing methods of classical instruction, and asserted that Latin and Greek might be learned in two-thirds of the time now bestowed upon them. And the other day, Mr. Froude, addressing the students of St. Andrew's on the occasion of his installation as their Lord Rector, in place of Greek recommended French, or German, or Chemistry, or Norman-French, or Chinese, or Russian, according to the wants of the individual. Such explosions of discontent keep the question of classical education in a lively condition.

In fact, complaints against the classics have grown so common of late that people begin to be weary of the question before any thing has been done to settle it. The cry that we have had enough of discussion about classics, and the sneer that every scribbler must have his fling at classics nowadays, are taken up with such heartiness by those interested in keeping things just as they are, that it is difficult sometimes to get a hearing.

To vindicate the right of speech on a question that deserves every ventilation, it may be sufficient to say that, if there were *more doing*, there might be *less talking*. It is contrary to all experience to suppose that, if there were a cessation of the talking, the authorities might in course of time begin to act. The importunate widow in the parable knew better than that. Believing that it is wise to discuss such a

[1] The present article is abridged from a pungent pamphlet reissued by D. Appleton & Co., and entitled "Classical Studies as Information or as Training." Should it be thought that what it says of the neglect of English applies to the state of things abroad, not here, we suggest a recent testimony upon this point. Dr. Manly, President of Georgetown College, Ky., in a commencement address, delivered last June, on Collegiate Reform, speaking of the branches of study that should be added to the course, said:

"Of these, one of the most important is the English language. The study of English grammar, commonly made a botch of in our schools, is usually entirely ignored in our colleges. Dogberry's philosophy appears to prevail, that "to read and write comes by nature." The student is presumed to be a "good English scholar" when he arrives at college; a very violent presumption, by the way, whether we consider either the chance he has had to learn, or the proofs he usually gives that he has learned. And even as to graduates, male and female, I scarcely venture to tell, what I have had abundant opportunities of knowing, in other States besides this, of the blunders they make in spelling, in pronunciation, in the plainest matters of propriety, and the simplest principles of grammar. And yet I do not hesitate to affirm that intrinsically and for its own merits, and then certainly more especially for us, who are to use it all our lives, there is no language the world ever saw more abundantly deserving, or more amply repaying, careful study than this same English tongue."

question to the utmost, and that the public should be grateful for the smallest contributions to the discussion, the writer of the present essay ventures to add his mite.

It will be found that in most cases the services claimed for the ancient languages are valuable services, and that, if a knowledge of these tongues could render one-tenth of the services alleged, it would be a serious crime to utter a word against their continuance as the staple of education. But what if, under the present mode of teaching classics, many of the alleged services are not rendered? And what if it be the case that, where certain services are rendered, or might be rendered, by a knowledge of classics, they are rendered, or might be rendered, in so far as they are desirable, more economically by other means? I propose to consider some of the arguments offered in defence of the classics, and to show that it would be better to replace Latin and Greek studies by the systematic study of English as the basis of a liberal education.

Among the arguments for the study of the classical languages, it is frequently urged that without it we cannot understand our own language. The English Schools Inquiry Commissioners for 1868 reported that "Latin has entered so largely into English that the meaning of a very large proportion of our words is first discovered to us on learning Latin, and to a no less degree has it entered into English literature, so that many of our classical writers are only half intelligible, unless some Latin precede the reading."

This argument is unsubstantial. Perhaps one man in a thousand of our countrymen has some smattering of Latin, fresh or faded; say one man in a hundred: do the Commissioners mean to aver that ninety-nine men in every hundred of us have not discovered the meaning of "a very large proportion" of what we say?

It is useless to reason with men capable of putting on record, or of accepting, such a proposition. It is useless to point out, what seems obvious enough, that the meaning of a word is determined not by its derivation, but by usage.

If anybody, after ten minutes' reflection, continues in such a belief, he had better have recourse to practical experiment. Let him call a servant a "slave," a sturdy rustic a "pagan," a Presbyterian father of a family a "pope." He will thus be delivered from his error very effectually, if not so agreeably as he might desire.

The same argument is put on a somewhat grander scale. Mr. Clark contends that, "whatever the subject-matter may be, no man can expound it with scientific precision unless he is acquainted with the etymologies and mutual relations of the terms he employs."

English Philology is doubtless an interesting study. Like other artists, the verbal artist takes a pleasure in the makers and the materials of his instruments. And some time might not unprofitably be devoted to the sources of the language, and the leading rules of verbal

change. That is all that can be said for the study of philology, and it is no small recommendation. To go Mr. Clark's length is a mistake. The meaning of *root* words, and the history of their transformation down to the present time, are no more essential to clear and effective composition than an historical knowledge of tools is essential to good carpentry; and the reason is manifest. The meaning of a word is determined not by its derivation but by usage. We can no more know the meaning of a word from the meaning of its etymon than we can know the size of a river at its mouth by going to its source.

Philological knowledge, however delightful, being a luxury, and therefore a secondary object, my space will not permit me to expatiate upon it. I make a brief statement.

The enormous acquisition of Latin and Greek is both insufficient and unnecessary.

It is insufficient. A thorough knowledge of Greek and Latin clearly will not help us in such parts of our vocabulary as are not derived from those sources.

It is unnecessary and even useless. The *roots* in English are computed at 500. The only rational way to study our philology is, to take up these roots, and trace their ramifications, so far as these have been ascertained. A collateral study would be the importation of words from various sources: for this purpose it would be ridiculous to master the syntax and literature of the various original languages. The main groups are determined by simple rules.

The philological argument assumes yet another form. The Latin scholar is supposed to have a peculiar advantage in scientific terminology.

Mr. Torr, a Lincolnshire farmer, examined before the Commissioners, says: "All botany and all chemistry have a sort of Latin derivation. There is a sort of knowledge of Latin in every thing. For instance, a man could not go into chemistry or botany without knowing the derivation and *finale* of every word."

In this matter, many argue as if the meanings of the original words were learned without an effort. The real state of the case is obvious enough. If the meaning of the original is adopted without change in the derivative, it can be learned as easily in English as in Latin. If the meaning of the original is not retained in the derivative, a knowledge of the one will be no aid toward the knowledge of the other.

Where several words come from the same root, let the common element be explained. If philology were really taught in our schools, as it might be were less time occupied with classics, the root-words in scientific nomenclature would be no less familiar to the average boy than they are at present to the best classical scholar.

We are told, furthermore, that English grammar cannot be taught without Latin grammar. "All masters," say the Commissioners, "ap-

pear to be agreed that nothing teaches English grammar so easily, or so well, as Latin grammar; and next to that they would place the teaching of some other foreign grammar, such as French." Mr. Clark, who carries all the favorite arguments for classics to such a height that he may be suspected of a covert design to make them ridiculous, alleges that "a youth who has mastered the Latin grammar, and learned to apply its rules, speaks and writes English without a fault, albeit innocent of Lindley Murray."

Is this argument verified by experience? On this point I might appeal to the individual reader. But we have definite testimony. We have the evidence of Mr. Dasent, who "has had considerable experience as an examiner" for military and civil service appointments. So far from certifying that Latin scholars "speak and write English without a fault," Mr. Dasent says: "I have known young men who write very good Latin prose, indeed, and very good Latin verse. I know what good Latin prose and Latin verse are, and I have known the same young men utterly incapable of writing a letter in their own language, or a decent essay." And again, "I think I know good writing when I see it, and I must say that some, who had great classical reputation, have been the worst English writers I have known. I have observed this over and over again. I have known men recommended solely in consequence of their university reputation, and I have found that they have been signal failures in English writing—splendid scholars, but utterly incapable of expressing themselves in their own tongue. They have no choice of words, and very often have a heavy, cumbrous way of expressing themselves." What could be stronger than this? Coming as it does from one of the few men qualified by experience to pronounce an opinion, this evidence is not to be lightly set aside.

Does the argument in question stand the test of reason? It is a common rejoinder to whatever is said against the existing system of education, that educational results are impalpable. Now, this is not one of the impalpable cases: a certain definite acquisition, the command of the literary usages of our language, is said to be conferred; the alleged possessors are tried and found wanting. However, for fear the evidence should not be considered wide enough, and the report of the Commissioners be adduced as counter-evidence, let us take the only other way of determining the point—let us apply the test of reason. We shall find that Latin grammar, so far from being the only means of teaching English grammar thoroughly, teaches hardly any English grammar. And not only so: what little English grammar it does teach indirectly, had better be taught directly.

How much English grammar is acquired through Latin grammar? The names of the parts of speech, and nothing else. Latin agrees with English in employing similar parts of speech. A Latin sentence, like an English sentence, is made up of nouns, adjectives, verbs, conjunctions, etc. Now, a boy that understands what a noun is, or an adjec-

tive, or a conjunction, in a Latin sentence, will probably know what name to give to words performing similar functions in an English sentence. If he knows that "cum" is called a preposition, and that "cum" means "with," he will probably be able to say that "with" is a preposition.

A pupil acquainted with English grammar, before commencing with Latin, has the same advantage toward knowing Latin grammar. If he has been taught to call "with" a preposition, and that "with" stands for "cum," he will probably be able to tell that "cum" is a preposition.

In the above I make a very full concession. It is extremely doubtful whether an ordinary boy would recognize an inflected part of speech in English, from knowing a similar part of speech in Latin. How many boys, if told that "bona" is an adjective, would make out that "good" receives the same grammatical name?

There is no further coincidence between English grammar and Latin grammar. The two languages have very different modes of inflection, whether for noun or for pronoun, or for verb, or for adjective, or for adverb; different concord, different government, different order; and, of course, different derivation and different composition. In all these respects—that is, in all the important or practical part of grammar—the usages of the two languages are wholly different. We cannot know English declensions from Latin declensions, English conjugations from Latin conjugations, English syntax from Latin syntax. Would a boy know that the past participle of *have* is *had*, from knowing that the supine of *habeo* is *habitum;* or, knowing the one, would he more easily remember the other? What boy, familiar with Latin declensions and conjugations, would discover by his unaided reason that there were such things as declensions and conjugations in English? Mr. Dasent's evidence clinches this. He bears witness of good Latin scholars that "they did not know even that there was any syntax or construction of the English language."

We are driven to conclude that this too common argument is an example of the error deplored by Mr. Mill—an example of using words without thinking of their meaning. Nobody, after remembering that Grammar is an account of the usages of a language, would be guilty of saying that the best way to get acquainted with the usage of one language is to study the usage of another.

It may be said that the knowledge of another grammar than our own helps our acquaintance with our own grammar, by way of contrast. True, but foreign usages may be illustrated well enough for this purpose with our own vocables. Take, for example, the inflections of Latin and Greek: what hinders the English teacher from showing that, in those ruder and less flexible tongues, relational particles were stuck on at the end of a word, instead of being placed before the word in a separate form? That, instead of saying "He struck with a

sword," a Roman would say "Sword-with-struck-he"—a partial advance on the agglutination of more savage dialects, where, instead of "He saw a pig on the road," we should have one word, "Road-pig-saw-he."

A classical education is also said to be the best training in English composition. This argument, in so far as the end alleged is gained through grammar, I have already shown to be groundless. I have still to deal with the direct exercise in English composition obtained in classical translation.

It is to be observed that this value is not special to Latin or Greek, but is common to all foreign languages. Further, if the idea of Mr. Mill and of some others were carried out, and we were able to read foreign tongues as we read our own, we should not translate at all, and could have no conceivable exercise in English composition. If we are exercised at all in English composition by foreign translation, it must be under some such system as the present mode of classical instruction. Is it impossible to write good English without a knowledge of classics? I need only repeat the stock answer. Some of the greatest names in our literature have won their reputation without a knowledge of classics.

Does the power of composing good English *always follow upon* a good knowledge of classics? Mr. Dasent's evidence, quoted before, gives to this question as explicit a denial as could be desired.

How far, then, is translation an exercise in English composition? Let us consider translation in detail. The pupil has to master the construction, that is, to recall the meaning of the relational particles and endings. He has to muster, partly from memory, partly from his dictionary, the English equivalents for the foreign words, settling which is the word for the occasion. Finally, he has to range the English words in the form of a sentence. This last is the exercise in English composition.

What proportion of the whole time given to translation does this exercise occupy? Sometimes hardly any time at all. The pupil prepares the meanings of the words, and blurts them out anyhow. In the most favorable cases, the time spent on this operation must be comparatively small. The other operations are much more arduous, and must occupy at least five-sixths of the whole time.

What is the nature of the composition done in this sixth of the translating time? Is it calculated to train in good English composition? On the contrary, literal translation is often insisted upon; that is to say, the pupil is drilled in unidiomatic English. This is worse than no English drill at all for purposes of English composition: its only effect in that direction must be to foster a habit of writing bad English.

Where the arrangement of the English words is made in accordance

with English usage, this sixth of the translating process becomes an exercise in the amendment of unidiomatic English. But the result is little more profitable than in the other case, for two reasons: One is, that the preliminary mustering of the main English words, and the puzzling over the constructions, absorb so much of the pupil's attention that the finished English rendering is little thought of. The other and principal reason is, that the English version, where attended to—as it must be in a good translation—is remembered only in connection with the Latin, and is not readily remembered when a natural object has to be described. A good translator has no facility in original composition, unless he has practised the art of composition by itself: the words used in translation do not occur as symbols for natural things, but only as equivalents for the Latin expressions. It was quite to be expected that Mr. Dasent would find good Latin scholars "utterly incapable of expressing themselves in their own language." The wonder would be if they found time to learn how to lay out felicitously their own thoughts and sentiments, while they acquired the art of felicitously translating the more or less skilful expression of the thoughts and sentiments of others.

Does the classical scholar acquire an abundance of words or skill in selecting the right words? In translating, he must cast about over various words of cognate meaning for the word that will suit the passage. Does he thereby learn a wide command of synonymes, and a dexterity in seizing the aptest word to convey his meaning? He learns a command of synonymes, undoubtedly. But where does he get them? Not in Latin; but in his own remembered store, and in the pages of the English lexicographer, his starting-point being some English equivalent of a Latin word. As a learner of synonymes, he does no more, and can make no more progress, than the non-classical pupil that ransacks his memory and his dictionary with a similar object. He does not learn to seize the aptest words to convey his meaning. What he learns is, to seize the aptest words to represent particular Latin words in particular contexts—an entirely different thing. Mr. Dasent's evidence on this matter is very pointed. It is his express complaint of good Latin scholars, that "they have no choice of words" in English.

Does classical composition train in English composition? In translating English into Latin or Greek, the pupil must acquire a certain familiarity with a certain number of English words. If the English be good, so much the better for the pupil. If he is taught to twist and turn it about, so as to make idiomatic Latin out of idiomatic English, so much the better for him. But the advantage is no greater than he would have by keeping passages of good English some time in his memory for any purpose whatsoever.

Let us now consider what can be made of English as an instrument of education.

Passages of English, more or less unsuited for children and often selected without method, are part of existing school-drill. This might be supplemented by attention to elocution, and practice in committing to memory, exercises that children are peculiarly apt for. Such exercises have the advantage of keeping the pupil occupied with the words of his own language, and storing him with a fund of expression.

Looking out the meanings is also a valuable exercise in greater or less present practice. In the hands of a skilful teacher this might lead to a wide command of synonymes. The highest form of this exercise would be the precise discrimination of synonymes. The want of some such early training is very marked in current literature. It is strange that men should know, or at least have spent much of their school-time in learning, the conjectured shades of meaning in Latin or Greek words, while they ride rough-shod over the delicacies of their own vocabulary.

Again, if Philology is to be studied, apart from Comparative Philology, it might be expected that boys should be taught the origin and changes in form and meaning of words they use daily, rather than crammed with the history of words they never use in after-life, and never view with any thing but a pedantic interest at the best.

A beginning might be made in philology at an early stage. The sources of words are determined by simple rules: it would be an easy task for beginners to apply these rules in referring words to their source, to decide whether words were taken from Latin, or Saxon, or Norman-French. A good exercise would be to Saxonize a whole Latinized paragraph, and inversely.

In discussing other studies in English I shall make a distinction between analytical processes and synthetical processes. Both occur in dealing with what usage permits—the province of Grammar—and also in dealing with what, within the compass of permissible usage, is best suited for its purpose—the province of Rhetoric. Analysis is otherwise known as construing, or parsing; synthesis, as constructing, or composing.

In the meagre share of our school-time now allotted to the teaching of English, very little is done toward the practice of these operations. This is all the more to be deplored, because the analysis of sentences and the principles of composition are not taught in connection with Latin or Greek. It is a great waste of energy to learn meanings and shades of meaning of so many vocables destined to total neglect as soon as they have been learned: the evil is aggravated when so much lumber is acquired without reference to principles applicable to all verbal compositions.

The grammatical analysis of sentences has lately been introduced into our schools. But the complaint is made that boys, though they soon learn to repeat glibly enough the hard terms used in that process, often fail to understand them. Now, what is the cause of this? It is due to two causes, both arising from the consumption of so much time

on Latin and Greek. Too little time is left for this analysis: none but teachers know the quantity of iteration and exemplification necessary to get an abstract notion into a boy's head. And there is no time at all for an exercise without which analysis can never be vividly understood, the opposite process of synthesis. Before a boy can be fully awakened to the gist of the terms of analysis, he must have applied them again and again to themes of his own composing, and there will be no time for such an exercise until there is an end of the classical supremacy.

The purification of the language from blunders is an urgent necessity. A good way of habituating the pupil to recognized usage would be to keep him working at collections of grammatical blunders. Were English made the systematic study that Latin has been, we should in this way effect, in the course of a generation or two, a great purification of our language. We have a good many collections of genuine idioms with examples of their violation; but we want a great many books of this kind—contributions from many workers in the same field. Latin is well provided for in this way. One cannot help regretting that so much time has been thrown away upon settling pure Latin usage that might have been spent so much more profitably in the purification of our own tongue.

So much for familiarizing the pupil with the parts of a sentence and correct grammatical usage. Practical teachers will recognize in what has been exhibited a wide field for school-study. Others will understand the amount of exercise involved, when they reflect upon the time now spent upon introductory exercises to Latin, of a much less extensive range than those I have indicated.

A knowledge of admissible forms of expression is more than Mr. Dasent seems to have found in several "good Latin scholars." But a youth that is master of this accomplishment is but indifferently equipped for recording and communicating his thoughts. Much imperfect expression passes current. A thing may be put a hundred ways, all conformable to grammar, yet one, and perhaps not many more than one, accords with the laws of good composition.

Can the principles of good composition be taught? Is rhetoric—the knowledge of good and bad in expression, viewed with reference to certain ends—a possible accomplishment for the school-boy? According to De Quincey, the end of rhetoric, as conceived by the ancients, was either ornament or fraud, figurative decoration or sophistry—a conception of rhetoric not so very rare in our day. The one end was served by the branches of rhetoric conversant with Tropes, Figures, and Emotional Qualities of Style; the other by the various maxims of Persuasive Art, consisting for the most part of shrewd devices for securing plausibility. I believe something more might be made of those branches of education than mere garnishing and trickery; still they are, perhaps, too advanced for the school-room. Be that as it

may, there are other parts of rhetoric that have a prior claim, because of more general value. De Quincey's account of ancient rhetoric is a fair enough summary; but of late years the canons of rhetoric have taken a wider scope. In Prof. Bain's "Rhetoric" or English "Composition," written with the scientific exhaustiveness and originality characteristic of the author, we have a great advance upon Aristotle. In addition to the old material completed and methodized, we have a body of rules bearing upon the order of words, the principles of the construction of sentences and of paragraphs, the principles of description, narration, and exposition. Of these subjects, the first four are admirably suited for the school-boy, description more than narration or exposition—although these also might be valuable—because it is regulated by a compact, complete, and easily-managed body of maxims.

What is there, then, to prevent this department of English composition from being practised in our schools, instead of composition in a dead language, where the sole ambition is to be grammatical? A variety of objections might be urged, which I proceed to discuss one by one. They will be found to disappear on consideration:

1. It may be said that *such studies are not ample enough* to keep our school-boys busy, and so fail in the most fundamental requisite of a school-study. How to arrange words, how to form sentences and paragraphs, how to make an easily conceivable description—why should not that be learned in a few lessons? If so, why are years spent in teaching our boys to avoid a few stock pitfalls in Latin composition? The reason is obvious. The rules or principles you may learn in a few lessons: you may not be perfect in the practice of these rules after years of study. The same thing is seen in every art. The pugilist or fencer soon learns the guards theoretically: it is a long time before he can promptly parry the hit or thrust of an adversary. The musician knows all the notes, and where he should place his fingers to bring them out, long before he can play at sight. We can all of us remember what we should have done: the opportunity is often past before we remember what we should do. In English composition, as in every thing else, theory and practice are two very different things. Take, for example, two points: how to place qualifying clauses in the most advantageous light for the words they qualify, and how to apportion the emphatic places of a sentence. These are embodied in Prof. Bain's work, and treated of in isolation, the one by Mr. Herbert Spencer, the other by Mr. Matthew Arnold. The principles are within the comprehension of any boy of ordinary intelligence. And yet they may be practised for years by a grown man without insuring infallibility in rapid composition. Here is a wide field for educational exercises, a field wide as the writings of the language, beginning with easy examples and reaching on to the more difficult. No expensive apparatus is required; wherever you have sentences written in English, you may fall to work. And the principles I have mentioned are but samples.

The difficulty is not to get work to overtake, but to overtake much of the work that waits for us.

2. It may be said that studies of this kind are mere elegant trifling. Admitted that classical studies are of no practical value except for discipline: admitted that these English studies contain all the elements of discipline; the one is as useless subsequently as the other; there is no reason for substituting the one for the other. I say that English studies have at least the advantage of keeping the pupil occupied with the words and correct usages of *his own language*, and that this, were there nothing else, is sufficient cause for change. But I say, further, that these studies can be so directed as to cultivate clearness and force of expression. Perhaps you deny this: you hold that clearness and force are natural gifts. That clearness and force are natural gifts, and that a teacher cannot communicate brains, nobody will care to dispute; but, that the devices and appliances for giving clearness and force to what they say can be communicated to boys of natural aptitude by a skilled teacher, I hold to be beyond question. All would not learn to compose English well, any more than all learn to compose Latin well; but some would learn; and no more can be said for any system of instruction.

3. It may be said that, granting careful tuition a help to acquiring clearness and force of expression, a good style can be formed only by familiarity with the best writers. I answer that this is no objection to the scheme we have considered. We made provision for the analytical as well as the synthetical study of English, rhetorical parsing as well as rhetorical practice. What I insist upon is, that we must have principles of good and bad in expression drilled into our boys, principles to be borne in mind both in analysis and in synthesis, in reading authors as well as in our own composition. Otherwise, how are we to know what to adopt and what to reject in an author, what to imitate and what to avoid; and how shall we escape the errors of Latinists that worship the conceits of Cicero, and adore the Patavinities of Livy? I quote from Dryden a striking confirmation: "Thus difficult it is to understand the purity of English, and critically to discern, not only good writers from bad, and a proper style from a corrupt, but also to distinguish that which is pure in a good author, from that which is vicious and corrupt in him. And for want of all these requisites, or the greatest part of them, most of our ingenious young men take up some cried-up English poet for their model; adore him and imitate him, as they think, without knowing wherein he is defective, where he is boyish and trifling, wherein either his thoughts are improper to his subject, or his expressions unworthy of his thoughts, or the turn of both is inharmonious."

4. It may be said that, granting the necessity of reading admired authors critically, that is, upon principles of good and bad, there are no good authors in English, and that the pupil should go with his

principles to classical Greek and Latin. Supposing there were no good authors in our tongue, the amendment of the bad would be as valuable an exercise as the recognition of the good. However, we should be glad to think with Macaulay: "It may safely be said that the literature now extant in the English language is of far greater value than all the literature which three hundred years ago was extant in all the languages of the world put together."

5. It may be said that, if composition were managed according to rule, there would be no scope for variety. That depends upon the nature of the body of rules. If the rule is absurdly narrow, obedience to it will result in a dead monotony. For example, on the unity of the sentence, Irving lays down that "different thoughts ought to be separated in the expression by being placed in different periods"—a rule that would reduce all composition to the movement of a jig. On the contrary, Prof. Bain recognizes that the matter of a sentence is determined by the rest of the composition, and gives the limitations of the absolute rule of unity. A principle of this kind, so far from inducing monotony, tends to assist variety: the writer is compelled to think of the matter of his sentences, and, in all probability, will thereby be prevented from the natural tendency to run them all together on the same model. Even if the rule were absolute, it would still be valuable, provided its reasons were assigned. The dull pupil would be dull all the same: the eager pupil, if he found the restrictions irksome, would either overthrow the reasons, or cast about for all variety within the letter of the law. Cut a root that intrudes into your garden, and the stump sends out twenty suckers for the one. You produce the same effect when you stop short an inquiring boy with a rule: the dull boy, a dead root, is little affected for good or for evil, but the clever boy is put upon his mettle, and becomes twice as active as before.

6. It may be said that *writing by rule, like walking on stilts*, must be a very cramped and constrained movement. The awkwardness in both cases is removed by practice.

7. It might be said that we should have *nobody to teach the new subject*. Such an evil would rapidly disappear. Many teachers are already competent, and all could without difficulty keep ahead of their first batch of pupils.

8. It will be said that no material for school-exercises has been accumulated, and that taking up an author at random would be unprofitable. It is not so; a good deal of such material has been accumulated. The reason why so little, comparatively, has been done, is plain enough. Our school-rooms have been occupied by a foreign invader, and the makers of school-books have been retained in alien service. For generations our boys have been condemned to anomalies in Greek and Latin gender, declension, and conjugation, Greek accents, Latin quantities, stiff constructions in Virgil, obscure allusions in Juvenal, various readings in Æschylus, years of study at things of no human use

or interest; and generation after generation of school-masters and book-compilers have been tortured to supply the means of torture. If the same amount of ingenuity had been expended upon English, our young writers might have been saved many a throe of composition, and our language many an ugly blemish. No one can tell how much the language might have been improved, and its superior modes and characteristics rendered habitual to the mass of our countrymen.

What I proposed to examine was whether classical studies should cease to be the staple of a liberal education, should in public institutions for general instruction form the basis of all scholarly acquirements. We seem to have reached the conclusion that Latin and Greek in that capacity should be replaced by English. There is no reason why such a change should involve the entire cessation of Latin and Greek studies. It would simply make Latin and Greek as other foreign languages are. It would make them optional, as Hebrew, Sanscrit, German, French. It would prevent the distorted view that we take of their importance, from their anomalous place in our education. It would enable us to survey them in their true light, as two—perhaps an important two, but still only two—of the great family of languages. Our conclusion is not that the study of Latin and Greek should be discontinued, but that, whatever acquisitions be intended for the schoolboy, the foundation of them all should be, not a knowledge of Latin and Greek, but a competent knowledge of his own language.

THE TRANSIT OF VENUS.

By HEZEKIAH BUTTERWORTH, Esq.

SOME of the world's greatest benefactors have worked with young minds, and one of the most remarkable discoveries of astronomical science was made by a company of English students in the best days of youth. We refer to the transit of Venus across the disk of the sun.

Our readers have doubtless noticed that Congress [1] has already made provision for the scientific observation of the transit in 1874. The subject will soon engage the attention of astronomers, for the phenomenon furnishes us with the most important elements of astronomical knowledge. By the visible movement of the planet across the sun's centre, we are enabled to determine the sun's horizontal parallax, or the difference between the real and apparent position of the sun,[2] and thereby to correctly calculate the distance of the earth and

[1] Congress has appropriated $150,000 to aid the observations, and has placed the United States Navy at the disposal of Messrs. Pierce, Henry, and Sands, to be employed for the purpose.

[2] The parallax of the sun, moon, or any planet, is the distance between its true and

the planets from the sun, and the magnitude of the heavenly bodies. No person now living ever saw the transit, nor will any of the present inhabitants of the earth, who see the wonderful visions of 1874 and 1882, ever behold them again.

The transits of Venus occur alternately at intervals of eight, one hundred and five and a half, and one hundred and twenty-one and a half years. The last transit took place in 1769,[2] before the American Republic had an existence, the next will occur in 1874, and the last that we shall ever see, in 1882. Nearly a century and a quarter will then pass away, to that strange-looking date 2004, ere the beautiful planet will impart her revelation to the astronomer on the sun's reflected image.

About the year 1635 there might have been found, in an obscure village near Liverpool, a young enthusiast of science, who, like Ferguson, turned away from the ordinary pastimes of youth to study the sublimities of the celestial scenery. He was beloved by all for his amiable disposition and his stainless life. Before he reached the age of eighteen he had mastered all the known problems of astronomical knowledge.

His name was Jeremiah Horrox. His father was a man of moderate means, but sympathized with his son's studious turn of mind, and, before the year 1633, placed him at Emanuel College, Cambridge.

The stormy times of the English Revolution were approaching. During the period in which the court and Parliament were occupied in the disputes that lost the first Charles his throne, four men (three of them were youths, and all of them intimately acquainted with each other) were employed in advancing the theory and practice of astronomy. They were, William Wilbon, William Gascoygne, James Crabtree, and Jeremiah Horrox, the subject of this sketch.

Possessing a sensitive, responsive nature, and always happier in loving companionship, the boy-astronomer Horrox made of James Crabtree, a youth in years but a sage in knowledge, a bosom-friend.

Horrox had but scarcely passed into his teens, before he became interested in the fact that the tables of Kepler indicated the near approach of the transit of Venus across the disk of the sun. It was a sight that no human eye had ever seen, and one which, if any human

apparent place in the heavens, the true place of any celestial object being that in which it would appear if seen from the centre of the earth.

[2] The year 1769, the birth-year of Humboldt, Cuvier, and Napoleon, is marked in the calendar of science by unusual achievements in the infant branches of experimental investigation. Chemistry had emerged from the mystical stage of alchemy, and was planted upon its firm inductive basis. Bergmann had just made the first analysis ever made of mineral waters. Black, Cavendish, and Priestley, had commenced investigations into the nature of different kinds of air; and, in 1769, Scheele first discovered the existence of phosphate of lime in bones. The experiments of Bakewell in sheep-breeding, the first step in the art of improving stock, which has been carried to such perfection during the last hundred years, also date their success from 1769.—Ed.

eye could see, would confirm all the deductions of the great German and Danish astronomers.

Often at night, as the boy Horrox stood before moonrise, gazing at the stars, and saw Venus—the Lucifer and Hesperus of the old classic poets—burning with a clear, steady flame, and casting a dim shadow over the vernal and midsummer fields, the thought would come to him that perhaps he, first among all the dwellers on the face of the earth, might see the planet, like a celestial messenger, darkening the solar centre.

The thought grew upon him, and haunted his waking dreams. In the hours that others spent in relaxation from toil, he studied and ciphered to see if the problems by which Kepler had fixed the date of the event had been accurately solved. The marvellous boy found an inaccuracy in the tables. Again and again he recast the figures of the great astronomer, with the same result. He calculated and recalculated the problems, until he himself wrought out a table by which it appeared that the next transit would take place on December 4, 1639.

We read of student-heroes, but what a proposition was this for a boy to demonstrate! Would the calculation indeed be verified by the event itself? Would the vision withheld from philosophers and sages, from the gray dawn of time, be first revealed to the eye of a boy—an humble boy?

Gassendi had noted the transit of Mercury a few years previously, the first that had ever been seen, and men of learning were discussing the discovery. Horrox aspired to follow up the triumph of Gassendi. He had proved the deductions of Kepler to be inaccurate, and he knew that he alone possessed the true knowledge of the phenomenon.

The imaginative years of youth flew by; his college-days passed, bringing him to the verge of manhood, and the looked-for time drew near.

Horrox met his young companions in science at times, and compared his astronomical observations with theirs, but to only one of them, his chosen friend Crabtree, did he confide the discovery that he had made of the near approach of the transit.

The memorable year arrived at length, and the memorable day came round. It was the Sabbath, a bright, shining day, clear and cool. In a room nearly dark sat the young astronomer, now twenty years of age. Engaged in devout thoughts, he awaited the fulfilment of his sublime dream. On a table before him lay a white sheet of paper on which to receive the sun's reflected image, over which the shadow of the planet would move like a dark spot, if indeed the boy's calculation were correct.

The sun mounted the deep-blue sky. The paper lay spotless before the expectant youth; no shadow broke the rim of its circle, and the hour for religious worship came.

The youth hears the call of the church-bells. Shall he heed it?

Before he shall return from the house of God, a cloud may overcast the sky, and the celestial disclosure may be lost for a century!

He asks his conscience what he must do. The inward voice seems to tell him that the Creator himself is more worthy of worship than the phenomena he has instituted of admiration. He resolved, if need be, to lose the vision, and keep his eye single to the glory of God alone.

When he returned from the service, he went to the darkened room. The sun was still shining clearly. He approached the paper. It was there—the round shadow on the luminous image.

He sat down, overcome with the fulness of his emotions. The shadow crept slowly along the bright centre, like the finger of the Invisible. Then he knew that the great principles of astronomy were true, and he saw that a new revelation of scientific truth awaited mankind.

There are moments in human experience that repay the toils and struggles of a lifetime. Such were those of Galileo when he raised the newly-made telescope to the heavens; such were those of Rittenhouse, when, a century after the discovery of Horrox, he saw the shadow of Venus again crossing the disk of the sun; and such were those that the boy-astronomer himself felt as he watched the dark spot—the mighty shadow of a planet in the far abyss of space—almost imperceptibly stealing across the circumference of the reflected circle on the paper. The sublimity of the youth's vision was as grand as the moral greatness of his soul.

His friend Crabtree, to whom he had communicated the secret, made the same discovery, by the same means, in a different place of observation.

The report of the discovery awakened a new interest in astronomical science throughout the world. Horrox was censured by men of culture for suspending his observations during the Sabbath service. He answered: "I observed the sun from sunrise to nine o'clock; again a little before ten, and lastly at noon, and from one to two o'clock—*the rest of the day being devoted to higher duties!*"

His work was ended. He fell a martyr to science, at the age of twenty-two. His companions in astronomical study also perished at an early age, two of them in the civil wars, and one of these at Marston Moor, fighting in defence of the crown.

The twilight of his young life was serene and cloudless. As his bodily strength decayed, he felt that his soul would soon rise in triumph over the glittering orbs on high, and join the pure in heart.

Nearly one hundred and thirty years passed before the transit of Venus was again visible. A transit had indeed occurred in 1761, but it did not fall within the observation of the astronomer.

The transit in 1769 was eagerly looked for because it was predicted. Expeditions were fitted out by the British, French, and Rus-

sian Governments, that it might be observed from widely-distant quarters of the globe. These went to Cape Wardhus, Kola, Cajaneburg, Otaheite, Fort Prince of Wales on the northwest of Hudson's Bay, St. Joseph and Santa Anna in California. The ingress of the planet was seen at almost all the observatories of Europe, the egress at Petersburg, Yakutsk, Uanilla, Batavia, Pekin, and Orenburg.

One of the principal observers, and perhaps the astronomer whose published observations were most highly valued, was David Rittenhouse. He, too, became an astronomer in boyhood, and used to calculate eclipses on the fences and on his plough-beam, when he stopped to rest in the field.

He, too, expectantly awaited the phenomenon, studying the theories and deductions that it involved by day and dreaming of them by night. He was assigned by the American Philosophical Society to Norriton, Pennsylvania, as his place of observation.

Rittenhouse possessed a highly-imaginative and sensitive nature; and when he saw, on the calm June day, the planet like a shadow, creeping, as it were, slowly along the edge of the solar disk, he became for some moments unconscious, overawed by the sublimity of the vision.

The transit of Venus, in 1874, occurs after an interval of one hundred and five and a half years.

TRANSITS.

1639, December 4th (N. S.) 1761, June 5th	121½ years.
1761, June 5th 1769, June 3d	8 years.
1769, June 3d 1874, December 8th	105½ years.

Venus, being the second planet from the sun, and the larger of the two inferior planets having their orbits within that of the earth, appears to the earth the most luminous of all the planetary stars, her light at the period of her greatest splendor being so intense as to cast a shadow. She is seen in her full orbit beauty in regions under the equator at the period of her greatest elongation. Her telescopic appearance is interesting, lofty mountains breaking her luminous circle. During her transits her atmosphere is distinctly visible.

Extensive preparations are making, in England and on the Continent, for observing the transit in 1874 and 1882, which will afford the means of the most careful and accurate results.

ON THE DERIVATION OF AMERICAN PLANTS.

By Prof. ASA GRAY.[1]

THE session being now happily inaugurated, your presiding officer of the last year has only one duty to perform before he surrenders the chair to his successors. If allowed to borrow a simile from the language of my own profession, I might liken the President of this Association to a biennial plant. He flourishes for the year in which he comes into existence, and performs his appropriate functions as presiding officer. When the second year comes round he is expected to blossom out in an address and disappear. Each president, as he retires, is naturally expected to contribute something from his own investigations, or his own line of study; usually to discuss some particular scientific topic. Now, although I have cultivated the field of North American botany with some assiduity for more than fifty years, have reviewed our vegetable hosts, and assigned to no small number of them their name and their place in the ranks, yet, so far as our own wide country is concerned, I have been, to a great extent, a close botanist. Until this summer I had not seen the Mississippi, nor set foot upon a prairie. To gratify a natural interest, and to gain some title for addressing a body of practical explorers, I have made a pilgrimage across the continent; I have sought and viewed in their native haunts many a plant and flower which, for me, had long bloomed unseen, or only in the *Hortus siccus*. I have been able to see for myself what species and what form constitute the main features of the vegetation of each successive region, and record—as the vegetation unerringly does—the permanent characteristics of its climate. Passing on from the eastern district, marked by its equally-distributed rainfall, and therefore naturally forest-clad, I have seen the trees diminish in numbers, give place to wide prairies, restrict their growth to the borders of streams, and then disappear from the boundless drier plains; have seen grassy plains change into brown and sere desert—desert in the common sense, but hardly anywhere botanically so—have seen a fair growth of coniferous trees adorning the more favored slopes of a mountain-range, high enough to compel summer showers; have traversed that broad and bare elevated region shut off on both sides by high mountains from the moisture supplied by either ocean, and longitudinally intersected by sierras which seemingly remain as naked as they were born; and have reached at length the westward slopes of the high mountain-barrier, which, refreshed by the Pacific, bear the noble forests of the Sierra Nevada and the Coast Range, and among

[1] Retiring Address of Prof. Gray before the American Association for the Advancement of Science, upon resigning the presidency, at the late meeting in Dubuque, Iowa, August 21, 1872.

them trees which are the wonder of the world. As I stood in their shade, in the groves of Mariposa and Calaveras, and again, under the canopy of the commoner redwood, raised on columns of such majestic height and ample girth, it occurred to me that I could not do better than to share with you, upon this occasion, some of the thoughts which possessed my mind. In their development they may perhaps lead us up to questions of considerable scientific interest.

I shall not detain you with my remarks (which would now be trite) upon the rise or longevity of these far-famed *Sequoia* trees, or of the sugar-pines, incense-cedar, and firs, associated with them, of which even the prodigious bulk of the dominating *Sequoia* does not sensibly diminish the grandeur. Although no account and no photographic representation of either species of the far-famed *Sequoia* trees can give an adequate idea of their singular majesty—still less of their beauty—yet my interest in them did not culminate merely nor mainly in consideration of their size and age. Other trees in other parts of the world may claim to be older. Certain Australian gum-trees (*eucalypti*) are said to be taller. Some, we are told, rise so high that they might even cast a flicker of shadow upon the summit of the Pyramid of Cheops. Yet the oldest of them doubtless grew from seed which was shed long after the names of the pyramid-builders had been forgotten. So far as we can judge from the actual counting of the layers of several trees, no *Sequoia* now alive can much overdate the Christian era. Nor was I much impressed with an attraction of man's adding. That the more remarkable of these trees should bear distinguishing appellations seems proper enough. But the tablets of personal names which are affixed to many of them in the most visited groves—as if the memory of more or less notable people of our day might be made more enduring by the juxtaposition—does suggest some incongruity. When we consider that a hand's-breadth at the circumference of any one of the venerable trunks so placarded has recorded in annual lines the lifetime of the individual thus associated with it, one may question whether the next hand's-breadth may not measure the fame of some of the names thus ticketed for adventitious immortality. Whether it be the man or the tree that is honored in the connection, probably either would live as long in fact and in memory without it.

One notable thing about these *Sequoia* trees is their isolation. Most of the trees associated with them are of peculiar species, and some of them are nearly as local. Yet every pine, fir, and cypress in California is in some sort familiar, because it has near relations in other parts of the world. But the redwoods have none. The redwood—including in that name the two species of "big trees"—belongs to the general cypress family, but is *sui generis*. Thus isolated systematically, and extremely isolated geographically, and so wonderful in size and port, they, more than other trees, suggest questions. Were they created, thus local and lonely, denizens of California only;

one in limited numbers in a few choice spots on the Sierra Nevada, the other only along the Coast Range from the bay of Monterey to the frontiers of Oregon? Are they veritable Melchisedeks, without pedigree or early relationship, and possibly fated to be without descent? Or are they now coming upon the stage (or rather were they coming but for man's interference) to play a part in the future? Or are they remnants, sole and scanty survivors of a race that has played a grander part in the past, but is now verging to extinction? Have they had a career, and can that career be ascertained or surmised, so that we may at least guess whence they came and how and when? Time was, and not long ago, when such questions as these were regarded as useless and vain—when students of natural history, unmindful of what the name denotes, were content with a knowledge of things as they now are, but gave little heed as to how they came to be so. Now such questions are held to be legitimate, and perhaps not wholly unanswerable. It cannot now be said that these trees inhabit their present restricted areas simply because they are there placed in the climate and soil of all the world most congenial to them. These must indeed be congenial, or they would not survive. But when we see how Australian *eucalyptus* trees thrive upon the California coast, and how these very redwoods flourish upon another continent; how the so-called wild-oat (*Avena sterilis* of the Old World) has taken full possession of California; how that cattle and horses, introduced by the Spaniard, have spread as widely and made themselves as much at home on the plains of the La Plata as on those of Tartary, and that the cardoon thistle-seeds, and others they brought with them, have multiplied there into numbers probably much exceeding those extant in their native land; indeed, when we contemplate our own race, and our own particular stock, taking such recent but dominating possession of this New World; when we consider how the indigenous flora of islands generally succumbs to the foreigners which come in the train of man; and that most weeds (i. e., the prepotent plants in open soil) of all temperate climates are not "to the manor born," but are self-invited intruders, we must needs abandon the notion of any primordial and absolute adaptation of plants and animals to their habitat which may stand in lieu of explanation, and so preclude our inquiring any further. The harmony of Nature and its admirable perfection need not be regarded as inflexible and changeless. Nor need Nature be likened to a statue, or a cast in rigid bronze, but rather to an organism, with play and adaptability of parts, and life and even soul informing the whole. Under the former view, Nature would be "the faultless monster which the world ne'er saw," but inscrutable as the Sphinx, whom it was vain, or worse, to question of the whence and whither. Under the other, the perfection of Nature, if relative, is multifarious and ever renewed; and much that is enigmatical now may find explanation in some record of the past.

The larger part of the genera of our own region which I have enumerated as wanting in California are present in Japan or Mantchooria, along with many other peculiar plants divided between the two. There are plants enough of the one region which have no representatives in the other. There are types which appear to have reached the Atlantic States from the South, and there is a larger infusion of subtropical Asiatic types into temperate China and Japan; among these there is no relationship between the two countries to speak of. There are also, as I have already said, no small number of genera and some species, which, being common all round or partially round the northern temperate zone, have no special significance because of their occurrence in these two antipodal floras, although they have testimony to bear upon the general question of geographical distribution. The point to be remarked is that a very large proportion of the genera and species which are peculiar to North America as compared with Europe, and largely peculiar to Atlantic North America as compared with the California region, are also represented in Japan and Mantchooria, either by identical or by closely-similar forms. The same rule holds on a more northward line, although not so strikingly. If we compare the plants, say of New England and Pennsylvania (latitude 45° 47′), with those of Oregon, and then with those of Northeast Asia, we shall find many of our own curiously represented in the latter, while only a small number of them can be traced along the route even so far as the western slope of the Rocky Mountains. And these repositories of Eastern-American types in Japan and neighboring districts are in all degrees if likewise. Sometimes the one is undistinguishable from the other; sometimes there is a difference of as great but hardly of as tangible character; sometimes the two would be termed marked varieties if they grew naturally in the same forest, or in the same region; sometimes they are what the botanists call representative species, the one answering closely to the other, but with some differences regarded as specific; sometimes the two are nearly of the same genus or not quite that, but of a single or very few species in each country, when the point which interests us is that this peculiar limited type should occur in two antipodal places and nowhere else. It would be tedious, and, except to botanists, abstruse, to enumerate instances, yet the whole strength of the case depends upon the number of such instances. I propose, therefore, if the Association does me the honor to print this discourse, to append in a note a list of the more remarkable ones. But I would mention two or three cases as specimens. Our *Rhus toxicodendron*, or poison-ivy, is exactly repeated in Japan, but is found in no other part of the world, although a species like it abounds in California. Our other species of *Rhus* (*R. venenata*), commonly called poison-dogwood, is in no way represented in Western America, but has so close an alliance in Japan that the two were taken for the same by Thunberg and Linnæus, who called them both *R. vernix*. Our

Northern fox-grape, *Vitis labrosca*, is wholly confined to the Atlantic States, except that it reappears in Japan and that region. *Wistaria* was named for a woody leguminous climber, with showy blossoms; native of the Middle Atlantic States. The other species which we prize so highly in cultivation, *W. sinensis*, is from China, as its name indicates, or perhaps only from Japan, where it is certainly indigenous. Our yellow-wood (*cladrastis*) inhabits a very limited district on the western slope of the Alleghanies. Its only and very near relative (*maackia*) is in Mantchooria. The *hydrangeas* have some species in our Alleghany region. All the rest belong to the Chino-Japanese region and its continuation westward. The same may be said of the *Syringas* (*Philadelphus*), except that there are one or two nearly the same in California and Oregon. Our blue choste (*cantophyllum*) is confined to the woods of the Atlantic States, but has lately been discovered in Japan. A peculiar relative of it, *diphyllæ*, confined to the higher Alleghanies, is also repeated in Japan, with a slight difference, so that it may largely be distinguished as another species. Another relative is our twin-leaf (*Jeffersonia*) of the Alleghany region alone. A second species has lately turned up in Mantchooria. A relative of this is *podophyllum*, our mandrake, a common inhabitant of the Atlantic United States, but found nowhere else. There is one other species of it, and that is in the Himalayas. Here are four most peculiar genera of one family, each of a single species in the Atlantic United States, which are duplicated on the other side of the world, either in identical or almost identical species, or in an analogous species, while nothing else of the kind is known in any other part of the world. I ought not to omit ginseng, the root so prized by the Chinese, and which they obtained from their northern provinces and Mantchooria. We have it also from Corea and Northern Japan. The Jesuit fathers identified the plant in Canada and the Atlantic States, brought it in the Chinese name by which we know it, and established the trade in it, which was for many years most profitable. The exportation of ginseng to China probably has not yet entirely ceased. Whether the Northeastern Asiatic and the Atlantic American ginsengs are exactly of the same species or not is somewhat uncertain, but they are hardly if at all distinguishable. There is a shrub—*ellittia*—which is so rare and local that it is known only at two stations on the Savannah River, in Georgia. It is of peculiar structure, and was without near relative until one was lately discovered in Japan (in Triwitalavia) so like it as hardly to be distinguishable, except by having the parts of the blossom in threes instead of fours. We suppose *ellittia* had happened to be collected only once, a good while ago, and all knowledge of the limited and secluded locality was lost; and meanwhile the Japanese form came to be known. Such a case would be paralled with an actual one. A specimen of a peculiar plant was detected in the herbarium of the elder Michaux, who collected it (as his autograph ticket shows) some-

where in the high Alleghany Mountains more than eighty years ago. No one has seen the living plant since, or knows where to find it, if haply it still flourishes in some secluded spot. At length it is found in Japan; and I had the satisfaction of making the identification. One other relative is also shown in Japan; and another has just been detected in Thibet. Whether the Japanese and the Alleghanian plants are exactly the same or not, it needs complete specimens of the two to settle. So far as we know, they are just alike. And even if some difference came to be known between them, it would not appreciably alter the question as to how such a result came to pass.

Each and every one of the analogous cases I have been detailing—and of which I could adduce very many more—raises the same question, and would be satisfied with the same answer. These singular relations attracted my curiosity early in the course of my botanical studies, when comparatively few of them were known, and my serious attention in later years, when I had numerous and new Japanese plants to study in the collections made (by Morris, Williams, and Morrow) during Commodore Perry's visit in 1853, and especially, by Mr. Charles Wright, in Commodore Rodgers's expedition in 1855. I then discussed this subject somewhat fully, and translated the facts within my reach. This was before I ever had developed the rich fossil botany of the arctic zone, before the immense antiquity of existing species of plants was recognized, and before the publication of Darwin's now famous volume on the "Origin of Species" had introduced and familiarized the scientific world with those now current ideas respecting the history of species, with which I attempted to deal in a moderate and feeble way. My speculation was based upon the former glaciation of the northern temperate zone, and the inference of a warmer period preceding (and, perhaps, following). I considered that our own vegetation, or its proximate ancestry, must have occupied the arctic and sub-arctic regions in Pliocene times, and that it had been gradually pushed southward as the temperature lowered and the glaciation advanced even beyond its present habitation; that plants of the same stock and kindred, probably ranging round the arctic zone as the present arctic species do, made their forced migration southward upon widely-different longitudes, and receded more or less as the climate grew warmer; that the general difference of climate which marks the eastern and the western sides of the continents—the one extreme, the other mean—was doubtless even then established, so that the same species and the same sort of species would be likely to secure and retain foothold in the similar climates of Japan and the Atlantic United States, but not in intermediate regions of different distribution of heat and moisture; so that different species of the same genus as in *torreya*, or different genera of the same group, as Redwood, *taxodium* and *glyptostribus*, or different associations of forest-trees, might establish themselves each in the region best suited to their particular re-

quirements, while they would fail to do so in any other. These views implied that the sources of our actual vegetation and the explanation of these peculiarities were to be sought in and presupposed an ancestry in Pliocene or still earlier times, occupying the high northern regions. And it was thought that the occurrence of peculiarly North American genera in Europe, in the Tertiary period (such as *taxodium*, *carya*, *liquidamber*, *sassafras*, *negundo*, etc.), might best be explained on the assumption of early interchange and diffusion through Northern Asia, rather than by that of the fabled Atlantis. The hypothesis supposed a gradual modification of species in different directions under altering conditions, at least to the extent of producing varieties, sub-species, and representative species, as they may be variously regarded; likewise the single and local origination of each type, which is now almost universally taken for granted.

The remarkable facts in regard to the Northeast American and Northeast Asiatic floras, which these speculations were to explain, have since increased in number, more especially through the admirable collections of Dr. Maximowits in Japan and adjacent countries, and the critical comparisons he has made and is still engaged upon. I am bound to state that in a recent general work by a distinguished botanist, Prof. Guisebach of Göttingen, these facts have been emptied of all special significance, and the relations between the Japanese and the Atlantic United States floras may be said to be more intimate than might be expected from the situation, climate, and present opportunity of interchange. This extraordinary conclusion is reached by regarding as distinct species all the plants common to both countries between which any differences have been discerned, although such differences would probably count for little if the two grew in the same country, thus transferring many of my list of identical to that of representative species, and by simply eliminating from consideration the whole array of representative species—i. e., all cases in which the Japanese and the American plant are not exactly alike. As if, by pronouncing the cabalistic word *species* the question was settled, or rather the greater part of it remanded out of the domain of science, as if, while complete identity of forms implied community of region, any thing short of it carried no presumption of the kind—so leaving all these singular duplicates to be wondered at, indeed, but wholly beyond the reach of inquiry. Now, the only known cause of such likeness is inheritance, and as all transmission of likeness is with some difference in individuals, and as changed conditions have resulted, as is well known, in very considerable differences, it seems to me that if the high antiquity of our actual vegetation could be rendered probable, not to say certain, and the former habitation of any of our species, or if very near relatives of them in high northern regions could be ascertained, my whole case would be made out.

The needful facts, of which I was ignorant when my essay was

published, have now been for some years made known, thanks mainly to the researches of Heer upon ample collections of arctic fossil plants. These are confirmed and extended by new investigations, the results of which have been indicated to me by the latter. The *taxodium*, which everywhere abounds in the Miocene formations in Europe, has been specifically identified, first by Goeppert, then by Heer, with our common cypress of the Southern States. It has been found, fossil in Spitzbergen, Greenland, and Alaska, in the latter country along with the remains of another form, distinguishable, but very like the common species; and this has been identified by Lesquereux in the Miocene of the Rocky Mountains. So there is one species of tree which has come down essentially unchanged from the Tertiary period, which for a long while inhabited both Europe and North America, and also at some part of the period the region which geographically connects the two (once doubtless much more closely than now), but survives only in the Atlantic United States and Mexico. The same *Sequoia* which abound in the same Miocene formations in North Europe has been now abundantly found in those of Iceland, Spitzbergen, Greenland, Mackenzie River, and Alaska. It is named *Sequoia langsdupii*, but is pronounced to be very much like *Sequoia sempervirens*, our living redwood of the Californian coast—to be the ancient representative of it. Fossil specimens of a similar, if not the same, species have been recently detected in the Rocky Mountains by Hayden, and determined by our eminent paleontological botanist, Lesquereux, and he assures me that he has the common redwood itself from Oregon, in a deposit of Tertiary age. Another *Sequoia* (*Sequoia sternbergii*), discovered in Miocene deposits in Greenland, is pronounced to be the representative of *Sequoia gigantea*, the big tree of Californian sierra. If the *taxodium* of the Tertiary time in Europe and throughout the arctic regions is the ancestor of our present bald cypress, which is assumed in regarding them as specifically identical, then I think we may with our present light fairly assume that the two redwoods of California are the probable descendants of the two ancient species which so closely resemble them. The forests of the arctic zone in Tertiary times contained at least three other species of *Sequoia*, as determined by their remains, one of which, from Spitzbergen, also much resembles the common redwood of California. Another, "which appears to have been the commonest coniferous tree on Disco," was common in England and some other parts of Europe. So the *Sequoias*, now remarkable for their restricted station and numbers, as well as for their extraordinary size, are of an ancient stock; their ancestors and kindred formed a large part of the forests which flourished throughout the polar regions, now desolated and ice-clad, and which extended into low latitudes in Europe. On this continent one species at least had reached to the vicinity of its present habitat before the glaciation of the region. Among the fossil specimens already found

in California, and which our trustworthy paleontological botanist has not yet had time to examine, we may expect to find evidence of the early arrival of these two redwoods upon the ground which they now, after much vicissitude, scantily occupy. Differences of climate, or circumstances of migration, or both, must have determined the survival of *Sequoia* upon the Pacific; very similar would seem to have been the fate of a more familiar gymnospermous tree, the ginko or *salistiria*. It is now indigenous to Japan only. Its ancestor, as we may fairly call it, since, according to Heer, "it corresponds so entirely with the living species that it can scarcely be separated from it," once inhabited Northern Europe and the whole arctic region round to Alaska, and had even a representative farther south in our Rocky Mountain district. For some reason, this and *glyptrophobes* survived only on the shores of Eastern Asia. *Libocearus*, on the other hand, appears to have cast in its lot with the *Sequoias*. Two species, according to Heer, were with the ancient ones in Spitzbergen. Of the two now living, one *L. decurrens*—the incense-cedar—is one of the noblest associates of both the present redwoods; the other is far south in the Andes of Chili. The genealogy of the *torreyas* is more obscure; yet it is not unlikely that the yew-like trees, named *taxides*, which flourished with the *Sequoias* in the Tertiary arctic forests, are the remote ancestors of the three species of torreya, now severally in Florida, in California, and in Japan. As to the pines and firs, these were more numerously associated with the ancient *Sequoias* of the polar forests than with their present representatives, but in different species, apparently more like those of Eastern than of Western North America. They must have encircled the whole polar zone then as they encircle the present temperate zone now.

I must refrain from all enumeration of the angiospermous or ordinary deciduous trees and shrubs, which are now known by their fossil remains to have flourished throughout the polar regions when Greenland better deserved its name, and enjoyed the present climate of New England and New Jersey. Then Greenland and the rest of the north abounded with oaks, representing the several groups of species which now inhabit both our eastern and western forest districts; several poplars are very like our balsam-poplar or balm-of-Gilead-tree; more beeches than there are now, a hornbeam, and a hop-hornbeam, some birches, a persimmon, and a plane-tree, near representatives of those of the Old World, at least of Asia, as well as of Atlantic North America, but all wanting in California; one *juglans*, like the walnut of the Old World; two or three grape-vines are near our Southern fox-grape or muscadine, the other near our Northern frost-grape; a *tilia*, very like our basswood of the Atlantic States, only a *liquidamber;* a magnolia, which recalls our *Magnolia grandiflora;* a *liriodendron*, sole representative of our tulip-tree; and a sassafras very like the living tree. Most of these, it will be noticed, have

their nearest or their only living representatives in the Atlantic States, and, when elsewhere, mainly in Eastern Asia. Several of them, or of species like them, have been detected in our Tertiary deposits west of the Mississippi by Newberry and Lesquereux. Herbaceous plants, as it happens, are rarely preserved in a fossil state, else they would probably supply additional testimony to the antiquity of our existing vegetation, its wide diffusion over the northern and and more frigid zone, and its enforced migrations under changes of climate. Supposing, then, that our existing vegetation, as a whole, is a continuation of that of the Tertiary period, may we conclude that it absolutely originated then? Evidently not. The preceding Cretaceous period has furnished to Caruthers in Europe a fossil print like that of the *Sequoia gigantea* of the famous groves, associated with pines of the same character as those that accompany the present tree; has furnished to Heer, from Greenland, two more *Sequoias*, one of them identical with a Tertiary species, and one nearly allied to *Sequoia languidrupii*, which in turn is a probable ancestor of the Californian redwood; has furnished to Lesquereux, in North America, the remains of another ancient *Sequoia*, a *glyptotrobus;* a *liquidamber*, which well represents our sweet-gum-tree; oaks, analogous to living ones, leaves of a plane-tree, which are also in the Tertiary, and are scarcely distinguishable from our own *Platanus Occidentalis;* of a magnolia- and tulip-tree; and "of a sassafras undistinguishable from our living species."

I need not continue the enumeration. The facts will justify the conclusion which Lesquereux—a very scrupulous investigator—has already announced, that "the essential types of our actual flora are marked in the Cretaceous period, and have come to us after passing, without notable changes, through the Tertiary formations of our continent." According to these views, as regards the plants, at least, the adaptation to successive times and changed conditions has been maintained, not by absolute reversals, but by gradual modifications. I, for one, cannot doubt that the present existing species are the lineal successors of those that garnished the earth in the old time before them, and that they were as well adapted to their surroundings then as those which flourish and bloom around us are to their conditions now. Order and exquisite adaptation did not wait for man's coming, nor were they ever stereotyped. Organic Nature, by which I mean the system and vitality of living things, their adaptation to each other and to the world, with all its apparent and indeed real stability, should be likened, not to the ocean, which varies only by tidal oscillations from a fixed level to which it is always returning, but rather to a river so vast that we can neither discern its shores nor reach its sources, whose onward flow is no less actual because too slow to be observed by the ephemera which hover near its surface or are borne upon its bosom. Such ideas as these, though still repugnant to some, and not long since to many, have so possessed the minds of the naturalists of

the present day that hardly a discourse can be pronounced or an investigation prosecuted without reference to them. I suppose that the views here taken are little, if at all, in advance of the average scientific mind of the day. I cannot regard them as less noble than those which they are succeeding. An able philosophical writer, Miss Frances Power Cobbe, has recently and truthfully said:

> It is a singular fact that when we can find out how any thing is done, our first conclusion seems to be that God did not do it. No matter how wonderful, how beautiful, how intimately complex and delicate has been the machinery which has worked, perhaps for centuries, perhaps for millions of ages, to bring about some beneficent result, if we can but catch a glimpse of the wheels, its divine character disappears.—("Darwinism in Morals," in *Theological Review, April*, 1871.)

I agree with the writer that this first conclusion is premature and unworthy; I will add deplorable. Through what faults or infirmities of dogmatism on the one hand, and skepticism on the other, it came to be so thought, we need not here consider. Let us hope, and confidently expect, that it is not to last; that the religious faith which survived, without a shock, the notion of the fixity of the earth itself, may equally outlast the notion of the absolute fixity of the species which inhabit it; that, in the future, even more than in the past, faith in an order which is the basis of science will not (as it cannot reasonably) be dissevered from faith in an Ordainer, which is the basis of religion.

VISUAL IMAGES IN DARKNESS.

THERE is a chapter in Sir John Herschel's volume of "Lectures on Scientific Subjects" which treats of certain peculiar forms of ocular spectra, under the above title.

The spectra here alluded to—those which present themselves to us, independently of the will, in darkness or when the eyes are closed—are familiar to us all; but it appears to me that the subject has certain bearings which have been hitherto overlooked, and which merit a passing notice.

In the first place, I must beg permission to quote Sir John's own words respecting the most frequently-occurring forms—those possessing perfect geometrical regularity:

"I find them," he says, "to be formed in darkness, and, if the darkness be complete, equally with open or closed eyes.

"The forms are not modified by slight pressure on the retina, but their degree of visibility is much and capriciously varied by that cause. They are very frequent; in the majority of instances, the pattern pre-

sented is that of lattice-work, the longer axis of the rhombs being vertical. Sometimes, however, the larger axes are horizontal. The lines are sometimes dark on a light ground, and sometimes the reverse. Occasionally at their intersection appears a small, close, and apparently complete piece of pattern work, but always too indistinct to be clearly made out.

"Occasionally the latticed pattern is replaced by a rectangular one, and within the rectangles occurs in some cases a filling-up of a smaller lattice-pattern or of a lozenge of filigree-work, of which it is impossible to seize the precise form, but which is evidently the same in all the rectangles.

"Occasionally, too, but much more rarely, complex and colored patterns like those of a carpet appear, but *not* of any carpet distinctly remembered or lately seen; and in two or three instances in which this has been the case the pattern has not remained constant, but has kept changing from instant to instant, hardly giving time to apprehend its symmetry and regularity, before being replaced by another; that other, however, not being a sudden transition to something totally different, but rather a variation on the former."

Thus far I have spoken of rectilinear forms; with myself, however, curvilinear forms more frequently present themselves. These so closely resemble the spectra which Sir John describes as having presented themselves to him when under anæsthetic influence, that I again quote his words:

"The indication," he says, "by which I knew it" (the chloroform) "had taken effect consisted of a kind of dazzles, immediately followed by the appearance of a very beautiful and perfectly symmetrical Turk's-cap pattern formed by the intersection of a great many circles outside and tangent to a central one. It lasted long enough for me to contemplate it so as to seize the full impression of its perfect regularity, and to be aware of its consisting of exceedingly delicate lines, which seemed, however, to be not single but close assemblages of colored lines not unlike the delicate fringes formed along the shadows of objects by minute pencils of light. The whole exhibition lasted, so far as I could judge, hardly more than a few seconds."

On the administration of chloroform a second time, after an interval of many months, "the Turk's-cap pattern again presented itself on the first impression, which I watched with some curiosity; but it was not quite so complete as, nor was it identical with the former. In the intersections of the circles with each other I could perceive small lozenge-shaped forms or minute patterns, but not clearly enough to make them well out. On both these occasions the colors were lively and conspicuous. . . . Since that time circular forms have presented themselves, spontaneously, of the shadowy and obscure class. On one occasion circular were combined with straight lines, forming a series of semicircular arches, supported by, or, rather, prolonged beneath into,

vertical columns, while another series of arches and uprights, darker than the general ground, appeared, intersecting the former, so as to have the dark uprights just intermediate between the bright ones of the first set. On the second occasion the pattern consisted of a very slender and delicate hoop, surrounded with a set of circles of the same size, as tangents to the centre circle and to one another. On the third occasion the whole visual area was covered with separate circles, each having within it a four-sided pattern of concave circular arcs. All these phenomena were much fainter than in the chloroform exhibition."

The accuracy of these descriptions will be readily admitted, as far as my own observations have enabled me to judge. I am, however, disposed to believe that the forms under which the spectra present themselves vary persistently in different individuals to a considerable extent.

A question now naturally arises: What are these spectra, and how are they formed?

An eminent scientific authority has suggested to me that they are *possibly* referable to that obscure mental process which Dr. Carpenter has termed "*unconscious cerebration.*" (*See* "Human Physiology.") But, allowing this to be the case, the questions put by Sir John Herschel still remain unanswered:

"Where do the *patterns* or their prototypes in the intellect originate?

"If it be suggested that a kaleidoscopic power of forming regular patterns, by the combination of casual elements, exists in the sensorium, how is it that we are unconscious of the power—unable to use it voluntarily—only aware of its being exerted at times in a manner in which we have actually no part but as spectators?"

I cannot help thinking that more than one of the most ancient types of symbolism upon which so much learning and ingenuity have been expended in endeavors to invest them with mystical meanings, or to trace their origin in the forms of the organic world, *may* have been first suggested by these hitherto-unnoticed spectra.

But besides these geometrical forms, there are others, which I must again describe in Sir John Herschel's words:

"I fancy," he writes, "that it is no very uncommon thing for persons in the dark, and with their eyes closed, to see, or seem to see, faces and landscapes. I believe I am as little visionary as most people, but the former case very frequently happens to myself. The faces present themselves voluntarily, are always shadowy and indistinct in outline, for the most part unpleasing, though not hideous, expressive of no violent emotions, and succeeding one another at short intervals of time, as if melting into each other. Sometimes ten or a dozen appear in succession, and have always, on each separate occasion, something of a general resemblance of expression, or some peculiarity of feature common to all, though very various in individual aspect and

physiognomy. Landscapes present themselves much more rarely, but *more distinctly*, and, on the few occasions I remember, have been highly picturesque and pleasing, with a certain, but very limited power of varying them by an effort of will, which is NOT the case with the other sort of impressions. Of course," he adds, "I am now speaking of waking impressions, in perfect health, and under no sort of excitement."

There is, of course, as Sir John Herschel observes, *one marked distinction* between these spectra and the *abstract* forms referred to at the beginning of this paper: "The human features have nothing abstract in their form, and they are so intimately connected with our mental impressions that the associative principle may easily find, in casual and irregular patches of darkness caused by slight local pressure on the retina, the physiognomic exponent of our mental state. Even landscape scenery, to one habitually moved by the aspects of Nature in association with feeling, may be considered in the same predicament. We all know," he adds, "how easy it is to imagine faces in casual blots, and to fancy pictures in the fire."

However this may be, I am inclined to think that we have here an, as yet, unacknowledged source of many widely-prevailing conceptions of the "world unseen."

If we are to believe with the eminent German mythologist, Dr. Swartz, that there was a time, strange as it may now appear, "when men had not yet learned to suspect any collusion between their eyes and their fancy;" when fast-scudding clouds were flying horses or fleeting swans; when the rolling masses of vapor in the west, as the day declined, were mountains in the far-off cloud-land—not in the sense of poetic figments, but in sober reality—we can scarcely doubt but that the shadowy resemblances of which we have just spoken would be, in like manner, regarded as real existences.

Even stopping short of this extreme view of the case, I think it is difficult to suggest a more probable origin for that universally-prevailing belief, which peoples the darkness with shadowy forms—the thousand fleeting shapes which

"Make night hideous;"

or of that equally wide-spread faith in the existence of hidden realms of enchantment, of which we have types in the mystic caves of Eastern story, and the glimpses of fairy-land in our own folk-lore.

It will be observed that the phenomena above described present themselves in *health*, and in the *absence* of *all* excitement.

Where these two conditions are wanting, both voluntary and involuntary spectra present themselves with greater frequency and distinctness. Medical works abound in such cases, and Sir J. Herschel gives several suggestive examples from his own personal experience, which space forbids my quoting here.

There is, however, one point to which he refers which should not be overlooked. Whatever views we may be disposed to entertain respecting either the mental conditions in which these phenomena originate, or the external agencies by which these conditions are produced or modified, there is reason to believe that the appearances themselves ARE really formed upon the retina of the eye, and THUS they may be fairly placed in the category of "THINGS ACTUALLY seen."—*Science Gossip.*

COAL AS A RESERVOIR OF POWER.

By ROBERT HUNT, F. R. S.

THE sun, according to the philosophy of the day, is the great storehouse of Force. All the grand natural phenomena are directly dependent upon the influence of energies which are poured forth without intermission from the central star of our system. Under the influences of light, heat, actinism, and electricity, plants and animals are produced, live, and grow, in all their infinite variety. Those physical powers, or, as they were formerly called, those imponderable elements, have their origin in one or other of those mysterious zones which envelop the orb of day, and become evident to us only when mighty cyclones break them up into dark spots. Is it possible to account for the enormous amount of energy which is constantly being developed in the sun? This question may be answered by saying that chemical changes of the most intense activity are discovered to be forever progressing, and that to these changes we owe the development of all the physical powers with which we are acquainted. In our laboratory we establish, by mechanical disturbance, some chemical phenomenon, which becomes evident to our senses by the heat and light which are developed, and we find associated with them the principle which can set up chemical change and promote electrical manifestations. We have produced combustion, say, of a metal, or of a metallic compound, and we have a flame of a color which belongs especially to the substance which is being consumed. We examine a ray of the light produced by that flame by passing it through a prism, and this analysis informs us that colored bands, having a fixed angle of refraction, are constant for that especial metal. Beyond this, research acquaints us with the fact that, if the ray of light is made to pass through the vapor of the substance which gives color to the flame, the lines of the spectrum which were chromatic become dark and colorless. We trap a ray of sunlight and we refract it by means of a spectroscope—an instrument giving results which are already described in this journal[1]—when we detect the same lines as those which

[1] *Popular Science Review*, vol. i., pp. 210–214.

we have discovered in our artificial flame. We pursue this very interesting discovery, and we find that several metals which give color to flame, and produce certain lines, when subjected to spectrum analysis, are to be detected in the rays of the sun. Therefore our inference is, that some substances, similar to the terrestrial bodies, with which we are familiar, are actually undergoing a change in the sun, analogous to those changes which we call combustion; and, more than this, we argue that the high probability is, that all solar energies are developed under those conditions of chemical change—that, in fact, the sun is burning, and while solar matter is changing its form, Force is rendered active, and as ray-power passes off into space as light, heat, etc., to do its work upon distant worlds, and these forms of Force are expended in doing the work of development *on* those worlds. This idea—theory—hypothesis—call it what we may—involves of necessity the waste of energy in the sun, and we must concede the possibility of the blazing sun's gigantic mass becoming eventually a globe of dead ashes, unless we can comprehend some method by which energy can be again restored to the inert matter. Certain it is that the sun has been shining thousands of years, and its influence on this earth we know to have been the production of organized masses, absorbing the radiant energies, in volumes capable of measurement. On this earth, for every equivalent of heat developed, a fixed equivalent of matter has changed its form; and so likewise is it with regard to the other forces. On the sun, in like manner, every cubic mile of sunshine represents the change of form of an equivalent of solar matter, and that equivalent of matter is no longer capable of supplying Force, unless by some conditions, beyond our grasp at present, it takes up again that which it has lost. That something of this kind must take place is certain. The sun is *not burning out.* After the lapse of thousands of years we have the most incontrovertible evidence that the light of to-day is no less brilliant now than it was when man walked amid the groves of Eden. We may venture farther back into the arcana of time, and say that the sun of the past summer has shone with splendor equal to the radiant power which, myriads of ages ere yet man appeared on this planet, stimulated the growth of those luxuriant forests which perished to form those vast beds from which we derive our coal. Not a ray the less is poured out in any hour of sunshine; not a grain-weight of matter is lost from the mass of the sun. If either the sunshine were weakened, or the weight of the vast globe diminished, the planets would vary in their physical conditions, and their orbits would be changed. There is no evidence that either the one or the other has resulted. Let us see if we can guess at any process by which this stability of the solar system is maintained.

It was first shown by Faraday, in a series of experimental investigations which may be regarded as the most beautiful example of in-

ductive science with which the world has been favored since Bacon promulgated his new philosophy, that the quantity of electricity contained in a body was exactly the quantity which was necessary to decompose that body. For example, in a voltaic battery—of zinc and copper plates—a certain fixed quantity of electricity is eliminated by the oxidation of a portion of the zinc. If, to produce this effect, the oxygen of a given measure of water—say a drop—is necessary, the electricity developed will be exactly that which is required to separate the gaseous elements of a drop of water from each other. An equivalent of electricity is developed by the oxidation of an equivalent of zinc, and that electricity is required for the decomposition of an equivalent of water, or the same quantity of electricity would be equal to the power of effecting the recombination of oxygen and hydrogen, into an equivalent of water. The law which has been so perfectly established for electricity is found to be true of the other physical forces. By the combustion—which is a condition of oxidation—of an equivalent of carbon, or of any body susceptible of this change of state, exact volumes of light and heat are liberated. It is theoretically certain that these equivalents of light and heat are exactly the quantities necessary for the formation of the substance from which those energies have been derived. That which takes place in terrestrial phenomena is, it is highly probable, constantly taking place in solar phenomena. Chemical changes, or disturbances analogous to them, of vast energy, are constantly progressing in the sun, and thus is maintained that unceasing outpour of sunshine which gladdens the earth, and illumines all the planets of our system. Every solar ray is a bundle of powerful forces; light, the luminous life-maintaining energy, giving color to all things; heat, the calorific power which determines the conditions of all terrestrial matter; actinism, peculiarly the force which produces all photographic phenomena; and electricity regulating the magnetic conditions of this globe. Combined in action, these solar radiations carry out the conditions necessary to animal and vegetable organization, in all their varieties, and *create* out of a chaotic mass forms of beauty rejoicing in life.

To confine our attention to the one subject before us. Every person knows that, to grow a tree or a shrub healthfully, it must have plenty of sunshine. In the dark we may force a plant to grow, but it forms no woody matter, it acquires no color; even in shade it grows slowly and weak. In sunshine it glows with color, and its frame is strengthened by the deposition of woody matter eliminated from the carbonic acid of the air in which it grows. A momentary digression will make one point here more clear. Men and animals live by consuming the products of the vegetable world. The process of supporting life by food is essentially one of combustion. The food is burnt in the system, developing that heat which is necessary for life, and the living animal rejects, with every expiration, the combinations,

principally carbonic acid, which result from this combustion. This carbonic acid is inhaled by the plant; and, by its vital power, excited by sunshine, it is decomposed; the carbon forms the ligneous structure of the plant, and the oxygen is liberated to renew the healthful condition of the atmosphere. Here we see a sequence of changes analogous to those which have been shown to be a law of electricity.

Every equivalent of matter changing form in the sun sends forth a measured volume of sunshine, charged with the organizing powers as potential energies. These meet with the terrestrial matter which has the function of living, and they expend themselves in the labor of producing a quantity of wood, which represents the equivalent of matter which has changed form in the sun. The light, heat, chemical and electrical power of the sunshine have produced a certain quantity of wood, and these physical energies have been absorbed—used up—in the production of that quantity. Now, we learn that a cube of wood is the result of a fixed measure of sunshine; common experience teaches us that, if we ignite that wood, it gives out, in burning, light and heat; while a little examination proves the presence of actinism and electricity in its flame. Philosophy teaches us that the powers set free in the burning of that cube of wood are exactly those which were required for its growth, and that, for the production of it, a definite equivalent of matter changed its form on a globe ninety millions of miles distant from us.

Myriads of ages before man appeared—the monarch of this world—the sun was doing its work. Vast forests grew, as they now grow, especially in the wide-spread swamps of the tropics, and, decaying, gathered into thick mats of humus-like substance. Those who have studied all the conditions of a peat-morass, will remember how the ligneous matter loses its woody structure in depth—depth here representing time—and how at the bottom a bituminous or coaly matter is not unfrequently formed. Some such process as this, continued through long ages, at length produced those extensive beds of coal which are so distinguishingly a feature of the British and American coal-fields. At a period in geological time, when an Old Red Sandstone land was washed by ocean-waves highly charged with carbonic acid, in which existed multitudinous animals, whose work in Nature was to aid in the building up masses of limestone-rock, there prevailed a teeming vegetation from which have been derived all the coal-beds of the British Isles. Our space will not allow of any inquiry into the immensity of time required for the growth of the forests necessary for the production of even a single seam of coal. Suffice it to say that, within one coal-field, we may discover coal-beds to the depth of 6,000 feet from the present surface. The section of such a coal-field will show us coal and sandstone, or shale, alternating again and again—a yard or two of coal and hundreds of feet of shale or sandstone—until we come to the present surface · every one of those deeply-buried

coal-beds having been at one time a forest, growing under the full power of a brilliant sun, the result of solar forces, produced then, as now, by chemical phenomena taking place in the sun itself. Every cubic yard of coal in every coal-bed is the result of a very slow, but constant, change of a mass of vegetable matter; that change being analogous to the process of rotting in a large heap of succulent plants. The change has been so slow, and continued under a constantly-increasing pressure, that but few of the gaseous constituents have escaped, and nearly all those physical forces which were used in the task of producing the woody matter of the plant have been held prisoners in the vegetable matter which constitutes coal. How vast, then, must be the store of power which is preserved in the coal deposits of these islands!

We are now raising from our coal-pits nearly one hundred and ten millions of tons of coal annually. Of this quantity we are exporting to our colonial possessions and foreign parts about ten million tons, reserving nearly a hundred million tons of coal for our home consumption. Not many less than one hundred thousand steam-boilers are in constant use in these islands, producing steam—to blow the blast for smelting the iron-ore—to urge the mills for rolling, crushing, and cutting with giant power—to twirl the spindle—and to urge the shuttle. For every purpose, from rolling cyclopean masses of metal into form to weaving silky textures of the most filmy fineness, steam is used, and this steam is an exact representative of the coal employed, a large allowance being made for the imperfections of human machinery. This requires a little explanation. Coal is a compound of carbon, hydrogen, oxygen, and nitrogen, the last two elements existing in quantities so small, as compared with the carbon, that they may be rejected from our consideration. The heat which we obtain in burning the coal is almost all derived from the carbon; the hydrogen in burning produces some heat, but for our purpose it is sufficient to confine attention to the carbon only.

One pound of pure coal yields, in combining with oxygen in combustion, *theoretically*, an energy equal to the power of lifting 10,808,000 pounds one foot high. The quantity of heat necessary to raise a pound of water one degree will raise 772 pounds one foot. A pound of coal burning should yield 14,000 units of heat, or $772 \times 14{,}000 = 10{,}808{,}000$ pounds, as above. Such is the theoretical value of a pound of pure coal. Many of our coal-seams are about a yard in thickness; several important seams are much thicker than this, and one well-known seam, the thick coal of South Staffordshire, is ten yards in thickness. This, however, concerns us no further than that it is useful in conveying to the mind some idea of the enormous reservoir of power which is buried in our coal formations. One square yard of the coal from a yard-thick seam—that is, in fact, a cubic yard of coal—weighs about 2,240 pounds avoirdupois; the reserved energy in that cube of coal is

equal to lifting 1,729,200 pounds one foot high. We are raising every year about 110,000,000 tons of coal from our coal-beds, each ton of coal being about a square yard. The heat of that coal is equal to a mechanical lifting power which it is scarcely possible to convey to the mind in any thing approaching to its reality. If we say it is 190,212,000 millions we merely state an incomprehensible number. We may do something more than this, if we can convey some idea of the magnitude of the mass of coal which is raised annually in these islands.

The diameter of this globe is 7,926 miles, or 13,880,760 yards; therefore the coal raised in 1870 would make a solid bar more than eight yards wide and one yard thick, which would pass from east to west through the earth at the equator. Supposing such a mass to be in a state of ignition, we can perhaps imagine the intensity of its heat, and its capability, if employed in converting water into steam, of exerting the vast force which we have endeavored to indicate. It was intimated last year in the House of Commons by a member of the coal commission that the decision of that body, after a long and laborious inquiry, would be that there existed in our coal-fields a supply for about one thousand years at our present rate of consumption. We have therefore to multiply the above computation by 1,000 to arrive at any idea of the reserved power of our British coal-fields. What must it have been ere yet our coal deposits were disturbed! At the time of the Roman occupation coal was used in this country. In the ruins of Roman Uriconium coal has been found. Certainly up to the present time a quantity of not less than three thousand million tons of coal has been dug out of our carboniferous deposits and consumed. All this enormous mass of matter has been derived from vegetable organizations which have been built up by sunshine. The sun-rays which compelled the plants to grow were used by the plant, absorbed, imprisoned in the cells, and held there as an essential ingredient of the woody matter. The heat, light, actinism, and electricity, which are developed when we burn a lump of coal, represent exactly the quantity of those forces which were necessary to the growth of the vegetable matter from which that coal was formed. The sunshine of infinitely remote ages becomes the useful power of the present day.

Let it not, however, be supposed that we employ all the heat which is available in our coal. All our appliances, even the very best, are so defective that we lose far more than we use. A pound of pure coal should evaporate thirteen pounds of water; in practice a pound of coal does not evaporate four pounds, even in the most perfectly-constructed steam-boilers, with the most complete steam-engines, such as have been constructed for pumping water for the Chelsea and the other water-works upon the Thames.

Numerous attempts have been made to burn our coal so as to secure a more effective result than this. There has been some advance, the most satisfactory being in the regenerative furnace of Mr. Siemens.

In this system the solid fuel is converted into crude gas; this gas is mixed with a regulated quantity of atmospheric air, and then burnt. The arrangements are essentially *the gas-producer*, or apparatus for converting the fuel bodily into the gaseous state; then there are *the regenerators*. These are sunk chambers filled with fire-bricks, piled in such a manner that a current of air or gas, passing through them, is broken into a great number of parts, and is checked at every step by the interposition of an additional surface of fire-brick; four of these chambers are placed below each furnace. The third essential is the *heated chamber*, or furnace proper. This, the furnace-chamber, communicates at each extremity with two of the regenerative chambers, and, in directing currents of gas and air upward through them, the two gaseous streams meet on entering the heated chamber, where they are ignited. The current descends through the remaining two regenerators, and heats the same in such a manner that the uppermost checkerwork is heated to nearly the temperature of the furnace, whereas the lower portions are heated to a less and less degree, the products of combustion escaping into the chimney comparatively cool. In the course of, say, one hour, the currents are reversed, and the cold air and gas, ascending through the two chambers which have been previously heated, take up the heat there deposited, and enter into combustion at their entrance into the heated chamber, at nearly the temperature at which the products of combustion left the chamber. It is not difficult to conceive that by this arrangement, and with its power of accumulation, any degree of temperature may be obtained in the furnace-chamber, without having recourse to purified gas, or to an intensified draught. Where the temperature of the melting-chamber has certainly exceeded 4,000 degrees of Fahrenheit, the products of combustion escape into the chimney at a temperature of only 240 degrees. The practical result of this regenerative system is stated to be, that a ton of steel requires by the ordinary method about three tons of Durham coke—which, being estimated as coal, will be about four tons—to melt it, whereas, in Siemens's furnace, the melting is effected with twelve hundred-weight of ordinary coal. This economy is produced by reserving the heat, by means of the regenerator, which is ordinarily allowed to escape by the chimney.

Another plan for consuming coal with economy has been recently introduced by Mr. T. R. Crampton, and is now in use at the Royal Arsenal, Woolwich, and at the Bowling Iron Works, in Yorkshire. Instead of converting coal into gas, as in the Siemens process, the coal is reduced by Mr. Crampton to a very fine powder, and then blown into the heated chamber by means of a fan-blast. By this arrangement the perfect combustion of the coal is produced, and a heat of the highest intensity can be obtained. The utilization of this heat, without waste, when it is produced, is an important question still requiring careful attention. There are several other experiments being carried

out with a view to the economical use of coal, but the two to which we have alluded give up to the present time the best results. Still, with these we allow more than one-half of the heat latent in the coal to escape us. The subtle element eludes our grasp—our charms are powerless to chain the sprite; he will not be bound to labor for us, but passes off into space, regardless of the human Prospero whose wand of science he derides.

In conclusion, our philosophy has enabled us to determine the heat-value of our coal-fields, and to prove that all this heat has a solar origin. Our science has shown us that, although we can eliminate all this heat, we cannot use it. There is an immense quantity constantly passing into space as radiant heat which we cannot retain.

The circle of action between the vegetable and the animal world is a beautiful and a remarkable provision. The animal burns carbon and sends into the air carbonic acid (a compound of carbon and oxygen); the vegetable breathes that carbonic acid and decomposes it; the carbon is retained and the oxygen liberated in purity, to maintain the life and fire-supporting principle of the atmosphere. Changes similar to these may be constantly going forward in the sun, and producing those radiations which are poured forth in volumes, far beyond the requirements of all the planets of our system. Although there is probably some circle of action analogous to that which exists upon this earth, maintaining the permanency of the vegetable and animal world, still there must be a waste of energy, which must be resupplied to the sun.

May it not be that Sir Isaac Newton's idea—that the comets traversing space gather up the waste heat of the solar system, and eventually, falling into the sun, restore its power—is nearer the truth than the more modern hypothesis, that meteorites are incessantly raining an iron shower upon the solar surface, and by their mechanical impact reproducing the energy as constantly as it is expended?—*Popular Science Review.*

SKETCH OF DR. CARPENTER.

By DANIEL DUNCAN, A. M.,

PROFESSOR OF LOGIC IN THE UNIVERSITY OF MADRAS.

WILLIAM BENJAMIN CARPENTER was born in Exeter, October 29, 1813. His father, Dr. Lant Carpenter, was a dissenting minister, favorably known as a writer on theological subjects. More widely known, however, as a zealous worker in the cause of juvenile reformation, is his sister, Miss Mary Carpenter. Only his earliest childhood was spent in Exeter, for in 1817 the family removed to Bris-

tol. Like several distinguished Englishmen of the present day, among whom are to be named Mr. John Stuart Mill and Mr. Herbert Spencer, Dr. Carpenter's subsequent achievements cannot be traced to the training received at any of the public schools; since his early instruction was carried on entirely under his father's roof. Besides the ordinary branches of an English lad's education, he devoted himself to physics and chemistry, for which he already showed a special taste and aptitude. His wish was to become a civil engineer, but, no suitable opening presenting itself at this time in that profession, he yielded to the desire of his family that he should study medicine. Mr. J. B. Estlin, a general practitioner of high standing in Bristol, and brother-in-law of Dr. Pritchard the ethnologist, having offered to take him as a pupil and apprentice to the medical profession, an engagement to this effect was entered into. This was in 1828. Besides receiving private instructions, Mr. Carpenter attended lectures at the Bristol Medical School, and at the Bristol Philosophical and Literary Institution, and had hospital practice at the Bristol Infirmary. In the winter of 1832, the state of Mr. Estlin's health rendering it desirable that he should make a voyage to the West Indies, Mr. Carpenter accompanied him to St. Vincent, where he stayed several months, and also visited the island of Grenada.

On his return to Bristol, Mr. Carpenter resumed his medical studies and practice. In 1834 he went to London, where he prosecuted his studies at University College and Middlesex Hospital. It was at this time, while attending the lectures of Dr. Grant on Comparative Anatomy, that he imbibed that special love for the subject which has resulted in the production of those volumes on Physiology by which he is most generally known. Having passed his examination at the College of Surgeons and the Apothecaries' Hall, he went in 1835 to Edinburgh, where he devoted himself to professional studies, under the able guidance of the distinguished men who at that time upheld the fame of Edinburgh University as one of the first medical schools in Europe. While here, he was elected the first of the four annual presidents of the Royal Medical Society.

After having spent two sessions in Edinburgh, Mr. Carpenter accepted the lectureship on Medical Jurisprudence in the Bristol Medical School, and at the same time commenced general practice in Bristol, intending to devote what spare time he might have to scientific pursuits. About this time he became a frequent contributor to various periodicals. Among the first of these contributions was a paper, "On the Voluntary and Instinctive Actions of Living Beings," published in the *Edinburgh Medical and Surgical Journal*. In the *British and Foreign Medical Review*, of which he eventually became the editor, his papers are remarkable alike for number and for varied contents. The first, which appeared in the July number of 1837, was on "Vegetable Physiology." This was succeeded in the following year by a

critique on that portion of Whewell's "History of the Inductive Sciences" which relates to physiology; and by an article on his favorite subject, "The Physiology of the Spinal Marrow," where the writer discusses the doctrine of reflex action which Dr. Marshall Hall had recently propounded as new. These are tolerably good beginnings for a young man of twenty-four years.

An impulse and direction were given to Mr. Carpenter's studies about this time, by his becoming possessed of a microscope, which a prize of thirty pounds, gained at Edinburgh University in 1837, for the best essay of that year, enabled him to purchase. He had already formed, and begun to execute, his design to write the now famous treatise entitled "General and Comparative Physiology," the first edition of which appeared in 1838. The scientific reader will not need to be told the general character of this work; and any account of it, to be of use to the non-scientific reader, would transgress the limits of this biographical sketch. Dr. Carpenter confesses that the course of study he had to go through in bringing out the work was of immense service to him, though it was rather detrimental than otherwise to success in the practice of his profession.

Up to this time the subject of this memoir had not received the degree of M. D. According to one of the regulations of the University of Edinburgh, a three-years' attendance was requisite for graduation; and when Mr. Carpenter accepted the post of lecturer at the Bristol Medical School he had only completed his second year. Now, however, a change in the rules enabled him to graduate in 1839 by an additional residence of three months. His thesis on the occasion of taking his degree—"On the Physiological Inferences to be deduced from the Structure of the Nervous System of Invertebrated Animals"—gained for its author one of the gold medals annually distributed. The views advanced by the essayist, though meeting with some opposition for a time, were at once adopted by Prof. Owen and others, and have since passed into general acceptance among scientific men.

The scientific aspects of medicine having from the beginning possessed attractions superior to the strictly practical, Dr. Carpenter resolved to devote himself wholly to the study of physiology, the delivering of lectures, private tuition, and writing. On being appointed Fullerian Professor of Physiology in the Royal Institution, he resigned his post in the Bristol Medical School, and came, in 1844, to London, where he has resided ever since. Hitherto he had been engaged chiefly in reducing to system the results of the investigations of others; as in his "Comparative Physiology," and "Human Physiology," the latter of which first appeared during this year. But about this time he began to be known as an original investigator, in connection with his researches into the microscopic structure of the shells of *Echinodermata*, *Mollusca*, *Crustacea*, etc. He was elected a Fellow of the Royal So-

ciety in 1844, and in the following year he obtained a lectureship at the London Hospital. A lectureship in geology was bestowed on him, by the trustees of the British Museum, in 1847, and in the same year he became one of the examiners of the London University. He also succeeded Dr. Forbes as editor of the *British and Foreign Medical Review*, to which he had been a constant contributor for years, and which was now amalgamated with the *Medico-Chirurgical Review*, under the title *British and Foreign Medico-Chirurgical Review*. Besides editorial supervision, he continued to contribute articles to this periodical, on a wide range of subjects. In 1849 he was appointed Professor of Medical Jurisprudence at University College, a post which he held for ten years.

Some six or eight years had already elapsed from the time when Mr. Grove first promulgated his views on the now well-known doctrine of the "Correlation of Physical Forces." As indicated by the title of his treatise, Mr. Grove did not attempt to show the equivalence of the so-called "vital force" with the physical forces; but confined himself to proving the mutual convertibility of the *physical* forces—motion, heat, electricity, light, magnetism, etc. In a memoir communicated to the Royal Society in 1850, Dr. Carpenter carried the argument further; he attempted to bring the "vital force" also within the generalization, proving that it has its origin in solar light and heat, and not, as is commonly believed, in a power inherent in the germ.

The reader will form an idea of the success of Dr. Carpenter's two principal works from the fact that, as early as in 1851, a third edition of the "Comparative Physiology," and a fourth of the "Human Physiology," were called for. Very high authorities have expressed their appreciation of these works, and the debt which recent physiology owes to them. Among these authorities may be mentioned Sir Benjamin Brodie, who, in his presidential address at the annual meeting of the Royal Society in 1861, said that Dr. Carpenter's works "have served, more perhaps than any others of their time, to spread the knowledge of those sciences, and promote their study among a large class of readers;" and that, "while they admirably fulfil their purpose as systematic expositions of the current state of knowledge on the subjects which they comprehend, they afford evidence throughout of much depth and extent of original thought on some of the great questions of physiology." The field where, perhaps, Dr. Carpenter has been most successful, is that border-land between the physical and the psychical, between matter and mind—the nervous system and its functions. He has also given his thoughts on another topic of present interest, in an article on the "Varieties of the Human Race;" where he argues strongly on physiological and psychological grounds for the specific unity of mankind.

In 1852 Dr. Carpenter relinquished the editorship of the *Medico-*

Chirurgical Review, on being appointed principal of University Hall—an institution for the reception of students at University College, similar to the halls at Oxford and Cambridge. By this change he was enabled to devote more time to scientific pursuits.

Of these pursuits a very important one was the study of the Australian and Philippine *Foraminifera;* the results of which were given in memoirs to the Royal Society, between 1856 and 1860. In these papers, says Sir B. Brodie in the address already referred to, Dr. Carpenter "described some remarkable types which were previously quite unknown; he gave a detailed account of the very complex organization existing alike in the foregoing and in types previously well known by *external* configuration; he demonstrated the entire fallacy of the artificial system of classification hitherto in vogue, the primary divisions of which are based on the plan of growth; he laid the foundation of a natural system, based on those characters, in the *internal* structure and conformation of the shell, which are most closely related to the physiological conditions of the animal; and, finally, by the comparison of very large numbers of individuals, he proved the existence of an extremely wide range of variation among the leading types of *Foraminifera*, often reassembling under a single species varying forms, which, for want of a sufficiently careful study, had not merely been separated into distinct species, but had been arranged under different genera, families, and even orders."

Another important series of subjects that engaged Dr. Carpenter's attention about this time was the phenomena of mesmerism, hypnotism, electro-biology, etc. The result of his investigations will be found in the *Quarterly Review* for October, 1853. In this paper he endeavors to explain the phenomena by *the automatic action of the mind under the influence of suggestion, the will being in abeyance.* The same explanation he considers applicable to all the phenomena of spiritualism, with the exception of those which are referable either to trickery or self-deception.

A detailed account of Dr. Carpenter's contributions to the general body of scientific knowledge would be out of place here. Let it suffice to say that he continued to prosecute with success his researches into the microscopic structures of organisms. In 1856 he published "The Microscope and its Revelations." New editions of his two great works on physiology being again urgently demanded, there was entailed upon him immense labor in reorganizing them and bringing them up to the highest level of that rapidly-advancing science. So great, indeed, has been the toil required to keep the successive editions of the "Human Physiology" (which is at present in its eighth edition) abreast of the times, that the author has of late years been compelled to hand over to others this important duty, while he himself has devoted all his spare time and energy to original investigation in certain departments of zoology.

In this self-imposed task it would still have been impossible for Dr. Carpenter to accomplish any thing very noteworthy, had he continued to be distracted by the multifarious engagements which occupied so much of his time during the first ten or twelve years of his stay in London. But, fortunately for him and for science, he was appointed, in 1856, registrar of the University of London. Though the duties of this office have considerably increased since he entered upon them, they still leave him many intervals of leisure for his favorite pursuits, while the salary attached to it is such as enables him to forego other engagements.

The Royal Medal awarded to Dr. Carpenter in 1861, by the Council of the Royal Society, was a well-earned recognition of the important services he has rendered to the cause of truth. And he has continued to lay us under additional obligations. For to him, as to other devoted students of Nature, the conquest of one field is but the prelude to yet further conquests. He has latterly been much occupied with a subject of special interest; to wit, the investigations connected with the deep-sea dredging expeditions, carried on in one of her Britannic Majesty's ships, and conducted by him, Mr. J. Gwyn Jeffreys, and Prof. Wyville Thompson. Though no final conclusions have as yet been arrived at, it seems to be clearly indicated that there is a vast sheet of the lowest type of animal life, which probably extends over the whole of the warmer regions of the sea. And there can be little doubt that, conducted by such experienced naturalists, these expeditions will result in correcting and enlarging our present knowledge regarding the distribution of life on the globe.

Dr. Carpenter is a man of much versatility of scientific attainment, of a philosophical cast of mind, inclining him to take broad views, with a good capacity of original investigations (although this is seen more in the speculative and generalizing field than in special experimental researches), and, withal, he is an unusually clear and able scientific writer. His election to the presidency of the British Association, at its Edinburgh meeting last year, was one of the highest honors that British science has to bestow. To guide the deliberations of the largest and ablest scientific body in the world, and to occupy the chair formerly filled by such men as Herschel, Whewell, Airy, Rosse, Stokes, Grove, Hooker, Huxley, and Thompson, is a tribute to Dr. Carpenter's worth and character which is doubtless as gratifying as it is just and deserved.

EDITOR'S TABLE.

PROFESSOR TYNDALL.

THIS distinguished scientific philosopher, it is expected, will soon arrive in this country to give several courses of lectures in the chief Atlantic cities. Many of our people have read and admired his books, and become deeply interested in his themes, and those who can will no doubt gladly avail themselves of this opportunity to witness his beautiful experiments, and listen to his eloquent expositions. Dealing as he does with the various branches of physical science, and the familiar agencies and operations of Nature in their latest philosophical interpretations, his lectures will be of a high order of interest, and arrest the attention of our most thoughtful and intelligent citizens.

The indebtedness of the people of the United States to European thinkers for works of genius and learning in all departments of literature and science is acknowledged, but we owe to Europe another debt for lending us now and then the living use of her great men. We are thus enabled to know not only what manner of books they write, but what manner of men they are, and to be brought immediately under the vital magnetic influence of their personalities. It was a great gain to American science when Prof. Agassiz left his foreign home and took up his abode in this country. His works would, of course, have produced an important influence, but that would have been as nothing to what he has been able to accomplish by his actual presence with us. Not only in his extensive original investigations by which our knowledge of Nature has been enlarged, and not only by the stimulus which he has given to multitudes of young men in the study of natural history, has he been of great service, but also by his public lectures, in all parts of the country, which have helped to increase the popular appreciation of these subjects.

A generation has now passed away since Dr. Lardner lectured in the principal towns in the United States to large and interested audiences, and the impulse he gave to the public mind in creating an interest upon these topics will produce its salutary effects for years to come. His general field of science was the same as that of Prof. Tyndall, but physics has made a long stride in the last thirty years. New departments of transcendent interest have been wholly created within this period. Dr. Lardner died the same year that Kirchhoff and Bunsen startled the world by the announcement of Spectrum Analysis. This was not only a new and splendid revelation which has thrown a flood of light upon many obscurities of Nature that science had never before dreamed of penetrating, but it was a new and powerful instrument of research of permanent value in the work of future discovery. Moreover, since the time of Lardner, new views of the energies of Nature of a most fundamental character have been arrived at. The doctrine of the correlation and conservation of force—"the highest law in physical science," says Dr. Faraday, "which our faculties permit us to perceive"—has been announced, elucidated, and established within the last generation. Dr. Lardner was too early for this subject; he belonged to the preceding epoch. As Dr. Whewell wrote the history of the science of heat without referring to the discoveries of Rumford in the last century — discoveries which involved a complete revolution in our views of

the nature of that agent as well as of dynamic philosophy—so Dr. Lardner went over the ground of physics in his five-years' lectures in this country in complete obliviousness of the new point of view that had even then been assumed by investigators of his own and other countries.

But Prof. Tyndall belongs to the later era: he has done his share in bringing it about, and is among its ablest representatives. Besides his original contributions to the more recent phases of science, by his genius for lucid and eloquent statement he has done perhaps more than any other man to put the new doctrines into popular and attractive form. In his classical volume entitled "Heat as a Mode of Motion," he takes the point of view definitely assumed by Rumford, and has worked out the science of thermotics on a modern basis and in harmony with the later views of the nature of force or energy. As all who have read his works are aware, Tyndall is more than a mere specialist; he is a broad thinker—a philosopher of science. No man is more painstaking or scrupulous in elaborating isolated facts with accuracy, but that does not content him, nor is he satisfied with the narrow theories that have been applied to them; but he strives after those wider and deeper explanations by which diverse phenomena are brought into harmonized relations. The various physical forces are interesting to him in their pure phenomenal workings, but they have a larger interest as clews to the constitution of matter. Physics has two great departments. Molar Physics treats of the movements and mechanical properties of masses, as the revolutions and attractions of the celestial orbs, or the laws of motion in terrestrial bodies. Molecular Physics, on the other hand, deals with the subtler forces of magnetism, heat, light, electricity, and affinity, by which the inner nature of matter is affected and its profoundest changes brought about. It is this division or aspect of physics that has mainly engaged the attention of Prof. Tyndall. His first scientific reputation was made by researches in the field of magnetism, and his original papers upon this subject have recently appeared in an elaborate volume. Glacial phenomena have also been favorite objects of study with him. Involving as they do the molecular mutations of water, through the vaporous, liquid, and solid conditions, on a grand and impressive scale, they afford a fine exemplification of the play of molecular forces of which Prof. Tyndall has availed himself, both to extend our knowledge of the subject and to enlist the interest of the public in some of the most beautiful and wonderful operations of Nature. The first book by which Prof. Tyndall became widely known was his "Glaciers of the Alps," now long out of print; and his latest work, to be immediately published, is on the "Forms of Water," in clouds, rain, rivers, ice, and glaciers. Much of his time during the last dozen years has been devoted to the revision and extension of his early opinions upon these subjects. The courses of lectures which he is to give in this country will be eminently valuable as reflecting the latest views that have been formed in a field of science that has undergone a great change within a recent period. We shall be able to listen to the authentic teachings of a master in science, and one who is, moreover, a master in the art of popular exposition.

THE PRESIDENTIAL ADDRESSES.

In our present number will be found the addresses of the presidents of the two scientific associations held in August, the one in Dubuque, Iowa, and the other in Brighton, England. They are entitled to consideration from the positions of their respective authors, the weight and dignity of the bodies addressed, and the interest of

the topics discussed. The presidency of these bodies is held as an eminent honor among men of science, to be filled but once in a lifetime, and then by gentlemen of the highest scientific ability. These addresses are read with interest throughout the scientific world, and they naturally call forth the best exertion that their authors are capable of making. In the present case the speakers have taken up the subjects to which their lives have been devoted, and upon which they are prepared to discourse with authority. This, however, is more especially the case with Prof. Gray. An accomplished botanist, who is, moreover, much of a philosopher, and can work at causes and effects in Nature as well as at identifying and labelling specimens, he has grappled with the profoundest question in his own domain, the origin, descent, and modifications of vegetable forms on this continent, and has handled it with a clearness, originality, and richness of illustration, which cannot fail to increase his already high reputation. Dr. Carpenter has won his best fame in the field of physiology, although cultivating successfully various branches of natural history. As is shown in the biographical notice which we publish, he has paid special attention to the physiology of the nervous system, and has worked out a mental philosophy on the basis of cerebral physiology. One of the doctrines to which he has paid much attention, and which he claims to have developed and extended so as to make it his own, was set forth by him in the lecture which we published last month, on the "Unconscious Action of the Brain." But while Dr. Carpenter has been an assiduous student of mind from this point of view, and is entitled to speak with authority upon the questions it involves, in the present address he has gone quite beyond this subject, and plunged into the utmost intricacies of metaphysics. His address contains much that is instructive in regard to the methods of science in interpreting Nature; and in addition to this he makes a vigorous attack on the new philosophical school that has lately grown up into strength within the circles of science. His argument is generally regarded as a protest and a reaction against recent and as many think mischievous scientific tendencies.

It is curious to note the course of thought for the past few years, in these two Associations, dedicated to the "advancement" of ideas, as that course is evinced by the leanings of the presidential speeches. Those of the American presidents have been cautious and timid, and they seem to have hesitated about committing themselves to "advanced" views. Prof. Gray is the first who has ventured officially to avow Darwinian doctrines. On the other hand, the later presidents of the British Association, Grove, Hooker, and Huxley, have been representatives of these doctrines. This year, however, the tendencies in both bodies would seem to be reversed—the American president breaking away from the conservatism of his predecessors, and the British president putting on the breaks to check the radical movement in his own body.

Yet Dr. Carpenter has neither arrayed himself against the doctrine of "Darwinism," nor is his scientific orthodoxy by any means above suspicion. He was among the first to assert and elaborate the great doctrine of the correlation of physical and vital forces, and, in the fifth edition of his "Principles of Physiology," he carried out the argument by including the mental forces in the correlated group. This doctrine was denounced as heretical and dangerous by Dr. Barnard, in his address before the American Association at Chicago, and, if we remember rightly, so great was the scare in England at the position taken by Carpenter, which was reprobated as rank ma-

terialism, that a paper had to be circulated, and eminent names obtained, certifying that it was all right, and that Dr. Carpenter was quite sound and safe in his views. As regards the present address, its main point involves the explicit acceptance of the view currently designated as "Darwinian."

The metaphysical conflict into which the doctor has thrown himself has reference to the mode of origin of our ideas. One school affirms that they are not a part of the order of Nature, that is, they do not come into existence by natural processes of growth and development. They are held to be intuitive, and formed directly by the Creator in a supernatural or extra-natural sphere. The opposite school maintains that ideas are not a part of the preconstituted original furniture of our minds, but grow and arise by experience in the regular order of Nature. Thus the intuitional hypothesis and the experience hypothesis are antagonist doctrines. Dr. Carpenter here proposes a compromise by calling in the principle of hereditary influence, or the power of habit to originate intuitive ideas in the course of generations. But, strange to say, Dr. Carpenter puts forth this view as his own, without recognizing that it is an old and fundamental doctrine of Herbert Spencer. It will surprise many that, upon so conspicuous and important an occasion, a theory of such undoubted moment in philosophy could have been put forth by Dr. Carpenter without the scrupulous recognition of its true authorship. Mr. Spencer's doctrine, long maintained, and fully elaborated in his system of Synthetic Philosophy, is that intuitions originate by slowly-organized experiences in the race, which are confirmed and accumulated through hereditary transmission as a part of the working of the great principle of Evolution. Dr. Carpenter indorses this view, and cites Mr. Mill as having recently given his adhesion to it, and his position is therefore substantially the same as that of Prof. Gray and the developmental school. But, in common with many others who hold to this theory, he strongly urges that it does not exclude the conception of efficient causation or of a supreme cause by which Nature is controlled, and, like Dr. Gray, he takes broad issue with the atheists. His view is summed up in the following closing passage of the address: "The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the *order* of Nature, it has separated itself wholly from theology, whose function it is to seek after its *cause*. In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. But when science, passing beyond its own limits, assumes to take the place of theology, and sets up its own conception of the *order* of Nature as a sufficient account of its *cause*, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends. For, while the deep-seated instincts of humanity and the profoundest researches of philosophy alike point to mind as the one and only source of power, it is the high prerogative of science to demonstrate the *unity* of the power which is operating through the limitless extent and variety of the universe, and to trace its *continuity* through the vast series of ages that have been occupied in its evolution."

HERBERT SPENCER AND DR. CARPENTER.

Since the foregoing remarks were put in type, we have heard again from the other side, and find that Dr. Car-

penter's error has received prompt and thorough correction. The *Daily Telegraph* closed a long editorial on Dr. Carpenter's address with a reference to the doctrine of modification of mental faculties through organized and transmitted experiences, and said: "It certainly is a striking theory, and for that reason the speaker might have been expected to avoid the pretence of treating it as if it were originally his own. The honor of opening up this new line of speculation belongs to Mr. Herbert Spencer more than to any other man, and yet not a word of recognition was paid to that eminent thinker. If we are to accept the doctrine, let us begin to practise justice on all occasions, so that posterity may have all the advantage, and that future presidents may display an instinctive equity in their addresses."

This called out the following from Dr. Carpenter:

To the Editor of the Daily Telegraph.

SIR: Observing that, in the comments on my Presidential Address which are contained in your leading article this morning, you impute it to me that I have adopted and put forth as my own a doctrine which really belongs to Mr. Herbert Spencer, I think it due to myself to state that, as you will see by the slip I enclose from the *Brighton Daily News*[1] of yesterday, I had supplied—before the delivery of my address—a reference to him, which had been inadvertently omitted from the copies issued by Messrs. Taylor and Francis to the London press, but which I at once transmitted also to the Association printers, to be included in all future copies.

I use the words "first explicitly put forth," because the germ of the doctrine is contained in a paper by Mr. T. Andrew Knight "On the Transmission of Acquired Peculiarities," published in the "Philosophical Transactions" for (I believe) 1837. His views had been introduced into my own "Physiological Treatises" long before my friend Mr. Herbert Spencer began his valuable labors.

Your obedient servant,
WILLIAM B. CARPENTER.

BRITISH ASSOCIATION, BRIGHTON, *August 16th.*

[1] "This doctrine was first explicitly put forth by Mr. Herbert Spencer, in whose philosophical treatises it will be found most ably developed."

Whereupon the President is again corrected by Mr. Spencer himself:

To the Editor of the Daily Telegraph.

SIR: Allow me to correct an error respecting date, into which Dr. Carpenter has naturally fallen from his unacquaintance with writings of mine earlier than those he names. It is true that "The Principles of Psychology," in which Mind is dealt with as a product of evolution, and in which the inheritance of accumulated effects of experience is recognized, not simply as producing "acquired peculiarities," but as originating the mental faculties themselves, emotional and intellectual, including the "forms of thought," was not published till 1855. But the doctrine which in that work took a developed and systematic form was set forth in an undeveloped form in works I published long before. Throughout "Social Statics," issued in December, 1850, it is taken as a cardinal principle: sundry leading ethical and political conclusions there drawn depend on the postulate that through inheritance there is a cumulative effect produced by the moral activities on the moral faculties—the discipline of social life gradually developing men into greater fitness for the social state (*see* pp. 33, 65, 413–441, first edition). Further back still is this idea traceable. Through a series of letters on "The Proper Sphere of Government," which I first published in 1842, and republished as a pamphlet in 1843, there runs a belief in human progression as wrought out by natural causes; and along with this there is shown, in its partial applications, the belief that in all creatures, man included, there goes on, through successive generations, a continuous adjustment of faculties, mental as well as bodily, to environing conditions.

While I have pen in hand, let me thank you for supplying the reference which, by the mischance Dr. Carpenter names, was omitted from the reports of his address in the daily papers. I am so much accustomed to see views of mine ascribed to others (as in this week's *Saturday Review*, p. 208, as well as in this week's *Spectator*, p. 1030), and I am so little accustomed to see a rectification made by any one on my behalf, that the close of your article on Friday produced in me the effect of a surprise.

HERBERT SPENCER.

ATHENÆUM CLUB, *August 18th.*

LITERARY NOTICES.

THE PHYSIOLOGY OF MAN. By AUSTIN FLINT, JR., M. D. Vol. IV. The Nervous System.

THE comprehensive work on Human Physiology, by Dr. Flint, approaches its completion; 2,000 pages of it are done, and another volume of perhaps 500 more will finish the treatise. This is the most considerable effort yet made by an American in physiology, and the work, by its extent and thoroughness, will prove an honor to American science. Although covering extensive ground, and dealing with a wide range of topics, Dr. Flint's work is by no means a mere compilation. Its author is a working physiologist; a careful and industrious experimenter, he has done much, both in the way of original investigation, and in testing and verifying the investigations of others. The first volume of the series treats of Blood, Circulation, and Respiration; the second of Alimentation, Digestion, and Absorption; the third of Secretion, Excretion, Nutrition, Animal Heat, Movements, Voice, and Speech; and the fourth of the interesting and complicated subject of Nervous Structure and Nerve-actions. This is the most obscure and difficult of all the branches of physiology, and it is consequently that division of the science in which clear and definite knowledge being most wanting, its place is supplied by speculation and hypothesis. Dr. Flint has been very careful to guard against the danger that here arises, and to limit his exposition to those facts and conclusions which may be regarded as fairly and decisively settled. In his preface, he says: "The present volume treats of the physiological anatomy and the functions of the nervous system, as they appear to a practical physiologist, accustomed to accept nothing that is not capable of positive demonstration or well-sustained inference. Adhering conscientiously to the positive method of study, the author has endeavored to present an account of the nervous system which, though it will undoubtedly be extended by future investigations, is made up mainly of statement of facts that will probably not undergo serious modification as we advance in our knowledge of the subject. He has considered the properties and functions of the cerebro-spinal and sympathetic nervous systems mainly from this point of view; and has touched but slightly upon psychology, which has long been considered a science by itself. The special senses have been deferred, to be taken up in the fifth and last volume of the series." Dr. Flint's work is written in a remarkably clear and agreeable style; and, although he would probably not himself claim that it is a popular treatise, as it must needs deal with many things that are unfamiliar to the common mind, and clothed in scientific language, yet his pages are nevertheless in a high degree attractive to all intelligent persons who are interested in the higher problems and processes of life. His work will be as valuable for reading and reference in the libraries of laymen as in those of the professional student, and for this purpose we know of no work upon physiological science that equals the present. It is just the treatise for reference in school libraries. Our popular physiological text-books are necessarily very meagre and often unsatisfactory, and it is therefore desirable that some larger work should be at hand for consultation. Flint's "Physiology of Man" will be well suited for this purpose, not only from its fulness and authenticity, but also from the convenience of its form, which is in several handy volumes, instead of an unwieldy single volume.

NIAGARA: its History and Geology, with Illustrations. By GEORGE W. HOLLEY. New York: Sheldon & Co.

AN instructive description of Niagara and its surroundings, not a mere traveller's guide to its sights and curiosities, but an account of it as a great natural phenomenon, was much needed, and the want has been well supplied by the neat little handbook just issued by Sheldon. The author observes in his preface that, of all places so extensively known, Niagara Falls is probably the least known; the mass of people being quite satisfied with it as a grand spectacular sensation. To the geologists, however, it has ever been an interesting study, while the number of those who share their interest, who care to *understand* it as well as to *see* it, to know something of its past and future as well as of its present, must

constantly increase, and these will find much to satisfy them in Mr. Holley's book. He has collected a great deal of historical information in regard to its early observations, gives full descriptions of its aspects and surroundings, makes a very clear statement of its geological character, and enlivens the whole with anecdotes, accounts of accidents, adventures, escapes, and personal sketches of men variously associated with its history. The earliest printed description of the cataract is now nearly two hundred years old. It was made by Father Hennepin in the winter of 1678–'79, and is a curious mixture of sober truth and childish exaggeration. He says: "Betwixt the lakes Ontario and Erie, there is a vast and prodigious cadence of water, which falls down after a surprising and astonishing manner, insomuch that the universe does not afford its parallel. 'Tis true that Italy and Switzerland boast of some such things, but we may well say they are sorry patterns when compared with this of which we now speak. . . . It (the river) is so rapid above the descent, that it violently hurries down the wild beasts, while endeavoring to pass it, . . . they not being able to withstand the force of its current, which inevitably casts them headlong above six hundred feet high. This wonderful downfall is composed of two great cross-streams of water and two falls, with an isle sloping along the middle of it. The waters which fall from this horrible precipice do foam and boil after the most hideous manner imaginable, making an outrageous noise, more terrible than that of thunder; for when the wind blows out of the south their dismal roaring may be heard more than fifteen leagues off."

MISCELLANY.

Bowlders of the Long Island Drift.—In a paper read before the Natural History section of the Long Island Historical Society, Mr. E. Lewis, Jr., gives an interesting account of the bowlders of the Long Island drift, treating especially of their size as compared with those of New England. On the north shore of the island, where the banks and headlands are rapidly wasted by the waves, bowlders, varying in size from a few inches to twenty feet in diameter, are thickly scattered about. Indeed, north of the central ridge of hills they are found everywhere, in some cases at an elevation of 300 feet above the sea-level. On Montauk Point, and in the neighborhood of the Hamptons, they are also abundant; and the immense deposits of sand along the southwestern shores were largely formed no doubt from bowlders and other materials of the drift, that have been ground up and deposited by the waves. This process is still going on, enormous quantities of bowlders and pebbles along the banks about Montauk being daily undermined and reduced to sand by the action of the surf. So far as observed, the bowlders are without sharp outlines, and many of them are exceedingly smooth. Those on the surface in the vicinity of Montauk have a blotched appearance, due to the presence of feldspar, and show evident traces of disintegration and decay. The excessive humidity of the air in this region is thought to contribute to this result.

Many of the bowlders are of large size, the largest being varieties of gneiss. Several have been carefully measured by Mr. Lewis. One on Strong's Neck, in Suffolk County, measures above the ground 22 by 26 feet, and is 25 feet high, giving a solid contents of about 14,000 cubic feet. At least half of this rock is believed to be below the surface. East of this are three masses of gneiss, which may have been originally one. If so, the volume of the mass could not have been less than 40,000 cubic feet; and if but two were originally united, of which there is reasonable certainty, the volume would have been about 27,000 cubic feet. Near Montauk are two masses of dark gneiss, one of which is, above the surface, 126 feet in circumference and 27 feet high, being somewhat cone-shaped. The other is about half this size. Not far from these is the finest though possibly not the largest specimen of gneiss upon the island. It is somewhat irregular in shape, compact in structure, and has a solid contents above the ground of 19,000 cubic feet. There are sections where bowlders, small and large, lie in masses that form continuous ledges.

The bowlders of Long Island, like those

of New England, indicate the enormous transporting power that was concerned in their removal. Long Island lies between 40° 34′ and 40° 10′ north latitude, and the 39th parallel is supposed to be nearly the southern limit of the drift; and, as a rule, toward its southern limit the drift is composed of small masses of material, but the dimensions of the Long Island bowlders prove that there may be exceptions to this.

The bowlders of the island and of New England appear to be similar in kind, dimensions, and distribution, and are believed by Mr. Lewis to have the same general origin. They also indicate but little diminution of the transporting power which distributed the bowlders of New England, and which so thoroughly modified its surface.

A New Entozoon from the Common Eel.—In the *American Naturalist* Dr. Samuel Lockwood describes a new parasite which he discovered embedded in the fat, or adipose tissue, on the entrails of the common eel. It has a proboscis which it can protrude from, or entirely retract into, its worm-like body, as into a conical sheath. This proboscis when extended is in the form of a cone, and is surrounded by rings of hooklets. At the extremity or point of this cone-like proboscis is a minute pore, which probably serves the purpose of a mouth. It is this spiny-armed organ which the animal forces by a slow motion into the fat, in and upon which it subsists. When the cone-like proboscis is withdrawn into the body of the animal, the forward end has a truncated appearance, and the entozoon is about one-eighth shorter than when the proboscis is extended. At this time the creature is less than a line in length. Dr. Lockwood has named the object *Koleops anguilla*. The first word, as denoting the habits of the animal, signifies *sheathed-head*, and the second, as denoting its habitat, is the technical name for the eel. Aside from the fact that this discovery has a general interest as an item of knowledge respecting the internal parasites of animals, it has a special interest to the helminthologist, as it makes the second genus of an order until now limited to one genus. On this point it is better to give the author's own words. Comparing this species with the *Echinorhyncus gigas*, long known to the student of the Entozoa, Dr. Lockwood says: "As to their ordinal relations, both are members of Owen's second class of the Entozoa, embracing the Sterelmintha or Solid Worms; and both evidently belong to Duvaine's Type IV., Acanthocephala or Spiny Heads, and to Randolph's Order IV., which bears the same name. Now, in this order there is but one genus, namely, Echinorhyncus, already mentioned; therefore we put in the order a new genus, to which we give the name *Koleops*, meaning *sheathed-head*, and species *anguilla*, because found in the common eel." Besides an extended description, the *Naturalist* gives good illustrative figures of the subject.

Insects and Flowers.—We are indebted to the report in the *World* for the synopsis of a paper read by Prof. C. V. Riley at the Dubuque scientific meeting, "On a New Genus in the Lepidopterous Family Tincidæ, with Remarks on the Fructification of Yucca"—one of the lily family.

Prof. Riley said that Dr. Engelmann, of St. Louis, had this year discovered that our yuccas must rely on some artificial agency for fertilization. The flowers are peculiarly constructed, so that it is impossible for the pollen to reach the stigma, it being glutinous and expelled from the anthers before the blossoms open. Prof. Riley, in investigating this subject, discovered that there was a small white moth that did the work, and he demonstrated on the black-board how marvellously the little insect was adapted to the purpose. This little moth, which he calls *Pronuba yuccasella* (yucca's go-between), was hitherto unknown to entomologists, and forms the type of a new genus. It is very anomalous from the fact that the female only has the basal joint of the maxillary palpus wonderfully modified into a long prehensile spined tentacle. With this tentacle, she collects the pollen and thrusts it into the stigmatic tube, and, after having thus fertilized the flower, she consigns a few eggs to the young fruit, the seeds of which her young larvæ feed upon. He stated that the yucca was the only entomophilous plant known which absolutely depended for fertilization on a single species of insect, and that insect so remark-

ably modified for the purpose. There was a beautiful adaptation of means to an end, and a mutual interdependence between the plant and the animal. Prof. Riley then explained succinctly how, on Darwinian grounds, even this perfect adaptation was doubtless brought about by slow degrees. He alluded, in closing, to a practical phase of the subject. The plant and its fructifier are inseparable under natural conditions, and the fructifier is found in the native home of the plant. In the more northerly parts of the United States and in Europe, where our yuccas have been introduced, and are cultivated for their showy blossoms, the insect does not exist, and consequently the yuccas never produce seed in those places. The larva of pronuba eats through the yucca-capsule in which it fed, enters the ground, and hibernates there in an oval silken cocoon. In this state the insect may easily be sent by mail from one part of the world to another, and our own florists may, by introducing it, soon have the satisfaction of seeing their American yuccas produce seed, from which new plants can be grown.

This paper was extremely interesting to every one present, and those who discussed it pronounced it in every respect admirable. Dr. Asa Gray, than whom no one in the country is better able to form a sound opinion upon such a subject, complimented Prof. Riley on his discovery, and the lucidity of his explanation before the section.

Binary Stars.—The same journal gives a sketch of a paper on this subject by Prof. Daniel Kirkwood, of which the following is a summary:

At the meeting of the Royal Astronomical Society of London, on May 18, 1872, it was announced by Mr. Wilson that a discussion of all the observations of the double star Castor, from 1719 to the present time, had led to the remarkable conclusion that the components are moving in hyperbolas, and, consequently, that their mutual relations as members of a system are but temporary. The fact, if confirmed, will be regarded with great interest, and its discovery will doubtless be followed by a minute and vigilant scrutiny of other binary systems.

But, while such a relation as that discovered by Mr. Wilson had not been previously suspected, its existence was certainly not altogether improbable. As the sun in his progressive motion through space compels such cometary matter as may come within the sphere of its influence to move about him in parabolas or hyperbolas, so two bodies of the same order of magnitude may be brought by their proper motions within such proximity that their mutual attraction shall cause each to move about the other in a hyperbolic orbit. Such instances, however, would seem to be exceptions to the general rule, as the motion of most binary stars is undoubtedly elliptic. (This fact has been explained in 1864 by the author on the basis of the nebular hypothesis.)

The components of Castor are of the magnitudes three and three and a half respectively. If we suppose that each before the epoch of their physical connection was the centre of a planetary system, the results of perturbation must have been extremely disastrous. The two stars were at their least distance in 1858.

This alleged discovery of a temporary physical connection between two fixed stars suggests a number of interesting inquiries. In the infinitely varied and complicated movements of the sidereal systems, different bodies may be brought into such juxtaposition as to change not only the direction of their motions, but also the orbits of their dependent planets. Some stars, at the rate of motion indicated by the spectroscope, would pass over an interval equal to that which separates us from the nearest neighboring systems in 20,000 years. In view of these facts, the conjecture of Poisson, that the temperature of the earth's surface at different epochs has depended upon the high or low temperature of the portions of space through which the solar system has passed, may not be wholly improbable.

A possible origin of binary systems is also indicated by Mr. Wilson's discovery. The cometary eccentricity of the orbits of these bodies is well known. In some cases the estimated distance between the components at the time of their periastral passage is less than half the radius of the earth's orbit. Now, if at the epoch of the

first nearest approach the radius of either star's nebulous envelop was greater than the distance between the centres of the two bodies, the atmospheric resistance would tend to transform the parabola or hyperbola, in which the body was moving, into an ellipse. Each subsequent return would shorten the period, until, in the process of cooling, the stellar atmosphere had so far contracted as no longer to involve any part of its companion's.

It would be an interesting question whether some of the double stars, whose apparent distance apart has seemed too great to justify the hypothesis of a physical connection, may not afford other instances of motion, either as parabolas or hyperbolas.

School-Life and Eyesight.—In a communication to the *Mechanics' Magazine*, Prof. Liebreich describes the injuries to the eye incident to school-life, pointing out their causes, and the means to be adopted to avoid them. The changes in the functions of the visual organ, developed under the influence of school-life, are three in number: First, decrease of the range of vision; second, decrease of the acuteness of vision; third, decrease of the endurance of vision.

Decrease of the range, short-sightedness (myopia), is developed almost exclusively during school-life—rarely afterward, and very rarely before that time. There is often an inherited predisposition to become short-sighted, and this is developed during school-life, more or less, according to certain external conditions. It is a common notion that short-sighted eyes are the most durable. This is founded on the fact that such eyes can see near objects distinctly without the aid of glasses, at an age when normal eyes require the assistance of convex lenses. But this is no proof of their durability. On the contrary, a high degree of short-sightedness is a diseased condition, caused by anatomical changes in the membranes of the eye, which involve a greater tendency to serious complication than the normal eye. Short-sightedness exerts an injurious influence on the general health by inducing the habit of stooping; and, from a national point of view, its increase is to be considered a serious evil.

Decrease of acuteness of vision (amblyopia) is a serious condition, generally the result of positive disease of the eye, which may exceptionally be induced at school. Amblyopia of one eye only, is, however, often produced by unsuitable arrangements for work, which disturb the common action of the two eyes, and weaken the eye which is excluded from use.

Decrease of endurance (asthenopia) is a frequent affection, that has destroyed many a career, prevented the development of many a fine intellect, and deprived many of the fruits of their laborious exertions. It arises principally from two causes: the first is a congenital condition, called hypermetropia, which can be corrected by convex glasses, and which cannot, therefore, be laid at the door of school-life; the second is a disturbance in the harmonious action of the muscles of the eye—a defect which is difficult to cure, and which is generally caused by unsuitable arrangements for work.

These three anomalies all arise from the same circumstances, viz., insufficient or ill-arranged light, or from a wrong position during work. Where the light is insufficient, or badly arranged, we are obliged to lessen the distance between the eye and the book while reading or writing; and we must do the same if the desks and seats are not of the right shape and size, and suitably located. When the eye looks at a very near object, the accommodating apparatus, and the muscles which turn the eye, are brought into a condition of extra tension, and this is to be considered as the principal cause of short-sightedness and its increase. If the muscles of the eye are not strong enough to resist such tension for any length of time, one of the eyes is left to itself; and, while one eye is being directed on the object, the other deviates outwardly, receives false images, and its vision becomes indistinct (amblyopia). Or, perhaps, the muscles resist these difficulties for a time, become weary, and thus is induced the diminution of endurance (asthenopia).

In order to prevent these evils, the light must be sufficiently strong, and fall on the table from the left-hand side, and, as far as possible, from above. The children ought to sit straight, and not have the book

nearer to the eye than ten inches at least. Besides this, the book ought to be raised 20° for writing, and about 40° for reading.

Ordinarily, minor considerations, such as the most compact disposition of the seats, or placing the pupils so that the teacher may the most readily look into their faces, govern the arrangements of the class-room, and, when any attention is paid to the matter of light, it is often to the detriment rather than the benefit of the class. For example: one of the rules laid down by the Educational Department in London, for the guidance of architects, is, that "the windows should be so placed that a full light should fall upon the faces both of the teachers and the children." Light coming from the right hand is not so good as that from the left, because the shadow of the hand falls upon that part of the paper at which we are looking. Light from behind is still worse, because the head and upper part of the body throw a shadow on the book or paper; but the light that comes from the front, and falls on the face, is by far the worst of all; for it not only defeats the object desired—illuminating the faces of the children—but is most hurtful to the eye. Instinctively desirous of avoiding the unpleasantness of the full glare, the children will assume all sorts of positions, which turn their faces from the master. In reading, they turn the head round the vertical axis, generally toward the right, in order to let the light fall on the book, which, when held straight before them, is completely in shadow; while, in writing or reading (the book being on the table), they bend their heads as low as possible, in order to shade their eyes by the projection of the forehead.

The best light for the school-room is from above; but, when this cannot be obtained, the desks should be so arranged, in connection with the windows, that the light shall fall upon the book or paper from the left.

Where light from gas or other artificial source is used for evening work, it should be made as steady as possible, and the lights so placed that they will not come opposite the eye, as in this situation they are dazzling and injurious. Ground-glass globes ought not to be used, for, though valuable in an ordinary room, where they tend to diffuse the light more equally, they give an indistinct light for work, and thus put a greater strain upon the eye. And, for the same reason, ground or ribbed glass should not be employed for the lower portions of windows, as the optical effect of such glass in that position is decidedly hurtful.

Jute.—This remarkable fibre, which formerly was only used for the coarsest purposes, has of late become invaluable. It makes a serviceable substitute for hair in chignons, and is now used extensively as a "mix" in silk. Owing to its kindly way of taking the dye, and the gloss which it sustains, a large quantity can be used in silk, and yet defy detection, except by an expert. It is, in consequence, highly desirable that it should be produced in our country, if possible. Some experiments by agriculturists are under way, which seem to promise success. Mr. F. T. D. Lacroix, of New Iberia County, Louisiana, has, on his plantation, several rows of the jute-plant, the seed of which was sent to him by the Department of Agriculture. The plants are very vigorous, and the indications are that jute will thrive in that climate. It bears some resemblance to flax in appearance, as it is said to in fibre.

A City's Waste.—Mr. Lepmann, director of the Central Trial Station, in Bavaria, speaks thus of the loss of fertilizers in Munich, a city of 177,000 inhabitants. He makes the sum of fertilizing elements wasted in the human excrements of the city for one year, 1,857,714 pounds of nitrogen, of which the commercial value is 866,934 gulden; 611,054 pounds of phosphoric acid, value 122,210 gulden; 372,375 pounds of potash, value 49,650 gulden; total value 1,038,794 gulden, equal to about $500,000. This sum would be still further increased by adding to it the value of the humus-forming constituents of the excrements wasted. To make up for that waste, he states that the amount of guano furnished by Peru yearly for the German fields is about 1,000,000 cwt.

Mr. Lepmann states that Germany now possesses a system by which he is confident this enormous waste may be entirely prevented, called there the Tonnen (barrel)

system. The city of Gratz, containing 80,000 inhabitants, has this system in use in every house, and has thus demonstrated the practicability of using it in large cities. As an illustration of the profit to be derived from human excrement when fairly tested as a fertilizer, Mr. Lepmann refers to the fact that, between the years 1850 and 1864, the price of that obtained from the barracks increased forty-five fold.

Mental Exertions governed by Law.—Prof. Heinrichs read a paper at the Dubuque scientific meeting, "On the Law of Probability as applied to the Determination of Mental Exertions." The following is a summary:

All phenomena in the physical world, exhibited by individuals of a mass subject to certain given influences, are regulated by the so-called law of probability. This has long been practically used by the various insurance companies, which employ millions of dollars a year; however uncertain the health of any given individual, the number of individuals dying each year in a mass of a hundred thousand individuals is perceptibly constant. So also the height of the stature of the individual in a greatly-varying quantity; but the number of individuals in an army having a certain definite height is very nearly constant, and determined by the law of probability. The application of this law of probability to the affairs of the individual man may be studied in the works of Quetelet. By several of our modern chemists the same law has been applied to the various chemical processes. If the laws which regulate mental work and mental phenomena are not radically different from those which we study in the physical world proper, then the law of probability ought to be equally applicable to the mental stature of man, as we long ago have found it to be applicable to the bodily stature of the same. By very careful determination of the relative grade of the individuals composing the large classes which have been instructed in the elements of physics at the State University of Iowa, the author has, during the past three years, had abundant means to test the applicability of the law of probability to mental exertions. The student's standing is determined by adding the numerical values of his credit for oral examination on the subject studied to the grade expressing his daily recitation and his practical work in the laboratory. Since these three quantities are determined independently of one another, and often by different persons (the class being instructed by the professor and two assistants), we have some guarantee against the accumulation of personal errors in this determination. Thus, in a class of sixty-seven students in the elements of physics, the following table shows the observed number of students per hundred who have obtained the standing given, also the calculated number of students who, according to the law of probability, should have obtained the same degree. It will be seen that the two numbers agree very closely:

NUMBER OF STUDENTS IN 100.

Standing.	Observed.	Calculated.
100	3.0	3.0
98	4.5	5.0
95	7.5	7.5
92	10.5	10.0
89	13.5	11.8
86	10.5	12.5
83	10.5	12.5
80	13.5	11.8
77	7.5	10.0
74	7.5	7.5
71	6.0	5.0
68	3.0	3.0
65	3.0	1.6

Dr. Hooker and the Kew Gardens.—The English papers have latterly had much to say of the difficulty between Dr. Hooker, Superintendent of the Kew Botanical Gardens, and Mr. Ayrton, a member of the Government, and Superintendent of Public Works. The Kew Gardens are part of an old royal park situated a few miles out of London, and have been developed to their present great extent and remarkable beauty, as well as in their scientific richness, mainly through the labors of the celebrated botanist Sir William Hooker, and of his son, Dr. Joseph Dalton Hooker, the present director. Without the genius, learning, enthusiasm, and, it may be added, the liberal pecuniary aid of these gentlemen, the Gardens would probably never have been created. They have been called into existence mainly through their agencies, and are now the pride of the nation, and are

visited and enjoyed by many thousands of people each year, while they are of immense value to students as a vast scientific treasure-house of the vegetable kingdom. But Ayrton, who has control of the Public Works, in which the Kew Gardens are included, a surly, grouty, ill-mannered, and meddlesome old politician, seems to have taken every occasion to make himself disagreeable to Dr. Hooker by impertinent interference with his management, and various kinds of insulting treatment. Dr. Hooker endured it as long as he could, but his position at length became so uncomfortable that he felt himself compelled either to resign or to appeal to the government to keep its bully somewhere within the bounds of decent behavior. When the facts became known, a committee of the most eminent scientific men of England, including Lyell, Tyndall, Busk, Huxley, Darwin, and others, drew up an elaborate statement of the case, and appealed to Mr. Gladstone to check the outrageous course of Ayrton, and make it possible for Dr. Hooker to continue his relations to the establishment. This waked up the press, who were not slow to ventilate the case, and the subject was at length brought before Parliament. The effect has been that the crabbed Superintendent of Works has received a sharp and thorough public rebuke, which will probably exert a salutary influence upon his future behavior.

The Work of the Coast Survey.—We copy from the *Tribune* the following notices of papers which were read at the late scientific meeting:

Prof. Benjamin Peirce, Superintendent of the United States Coast Survey, gave an exceedingly interesting account of the measures taken by that Bureau with reference to stations for astronomical observations at great heights, such as Sherman, on the Rocky Mountains. Prof. Young, of Dartmouth College, was selected by Prof. Peirce as the proper astronomer to determine the best position for astronomical observations. In a higher position you get rid of absorption of light by getting rid of half the atmosphere. This problem Prof. Young was specially adapted to investigate, as his knowledge of spectrum analysis is superior to that of any other man in this country. Prof. Young reports the whole number of lines in the chromosphere seen from Sherman as 150, which is three times as great a number as have been observed before. This fact alone shows that higher points should be resorted to for astronomical observations. Telescopes will hereafter be placed at points higher than ever before—in Europe probably on the Alps. The next element of success depends upon the steadiness of the atmosphere. It can be said in reference to this, that a star has been recognized at these high altitudes as having a companion, or being a double star, not previously known as such. An observer on the Pacific coast reports to Prof. Peirce that he can see the companion of the star Polaris from a high point on the Sierra Nevada. It is well known that this is a test of great nicety, requiring the utmost purity of atmosphere. As to the character of the observations for precision, there are not yet sufficient observations to determine it. The evidence is already at hand to show that at some of these elevated points an observatory should be established. The best work in astronomy is done in the few best nights at any place, and by these alone the value of the position must be determined.

Prof. J. Lawrence Smith adverted to the extreme brilliancy of stars in those regions. West of Sherman the air is so dry that even the lips of observers crack, and their health is otherwise affected. He thought that more exact observations upon the planets and satellites would be made from those lofty points which would add as much of interest to this department of astronomy as did the recent discoveries in stellar analysis. It was resolved that Prof. Peirce should be added to the committee to press this matter of elevated astronomical stations upon the Government of the United States.

Prof. Peirce showed that the necessities of the Coast Survey extended its operations to all parts of the United States. No science could be divided and separated so as to stand alone. If one begins by measuring his town-lots, the method involves geometry and astronomy, geology and surveying, including ultimately the coast survey. To prove the paths by which vessels can best

traverse the ocean, to test the best methods by which $2,000,000,000 of values shall be carried from the West to the East, from the East across the Atlantic, or from the shores of China and Japan to the Pacific coast, and thence across the country, was the business of the Coast Survey. All the United States is deeply interested in every part of this subject. Every ship that is lost by imperfectly-surveyed harbors is a loss to the whole country. A few great harbors—New York, Boston, Savannah, San Francisco—are vital points of commerce. The merchants of those cities are ever ready, by extending wharves and pushing out piers, to gain individual advantages while ruining the harbors. The Coast Survey is the bulwark against these encroachments. This matter should be in the hands of the General Government, and Congress should pass laws to prevent these injuries. If the coast survey were thorough, and maps were fully representative of ascertained facts, a pilot would scarcely be necessary, but yet never could be entirely dispensed with, especially in bad weather. The worst rocks have generally been discovered by the misfortune of striking upon them. Under such circumstances the pilot becomes a more accurate observer than the plummets of the Coast Survey. This was curiously illustrated by instances where pilots had taken out parties engaged in coast survey, and asked to have a plummet dropped at a spot apparently out at sea with nothing to guide it, and the surveying parties have found this strange instinctive knowledge of the pilot fixed the very spot of a dangerous sunken rock which could never have been found otherwise. The pilots discovered that, by putting down every rock that they knew of, they made maps that frightened the captains of vessels into employing them. Hence these practical observers have added immensely to the number of facts accumulated by the Coast Survey.

Prof. Peirce explained why he considered it unnecessary to carry out at present so thorough a survey of the Pacific as has been made of the Atlantic coast. The needs of the commerce of the coast is the standard by which the work of the survey is determined. He took occasion to mention that the Hassler Expedition was at the expense of private individuals, principally of Boston, and was not at the expense of the Government. Different States obtained the benefit of the coast survey by the determination of fixed points for their own interior topographical and geological surveys. A general geodetic connection has been effected in these observations, so that the whole United States will benefit by them; and the points will be taken so as eventually to procure a complete survey of the whole continent, passing through each State and the large cities. It is a work that may take a century. It is the hope of Prof. Peirce that this survey will not only be the best in the world, but that its details will be such that before long there will be no necessity for railroad surveys—the facts will be spread everywhere. As to the higher operations of the Coast Survey, their ultimate expression will be an accurate determination of the figure of the earth. Its actual figure as an ellipsoid of revolution is not yet actually known. It is one of an infinite number of possible figures, each nearly an ellipsoid of revolution. This question may ultimately be determined by observations on this continent. Observations here are more successful and free from local irregularities than in Asia or Europe. Yet there are some such local irregularities here—notably one near Boston, where there is some strange deviation of density from the surrounding country.

THE FEMALE THE BETTER HALF.

If there were able debaters among the members of the Association present, opportunity has certainly not been wanting in which to develop their ability. Think, for instance, of what a magnificent subject for discussion was offered by Prof. Hartshorne, of Pennsylvania, in a paper on the relation between organic vigor and sex, in which he espoused the theory that the births of females were an indication of excess of formative force, and of males of a deficiency, on the part of the parents; and that female offspring was an index of the highest vigor. He began by alluding to certain papers which Prof. Meehan, a botanist of celebrity, had submitted to the Association, wherein it was set forth that the highest types of vegetation among the larch and coniferous

trees were of the female kind. He specifies that the larch, while in its highest luxuriance, and during many years, produces only female flowers; but in its decline it at length produces male flowers, and it shortly afterward dies. Prof. Hartshorne extended this theory to animal life, and undertook to show that, whenever or wherever there was excess of formative power, its tendency was to the production of female offspring. He illustrated his belief by the development of bees, the birth of the queen-bee being the highest, of the drone the lowest result, and preceded by respectively high and low circumstances of nutrition. Sometimes a working-bee — which, being an imperfect female, is of course incapable of impregnation—will give birth to parthenogenetic offspring. Such offspring is always male. The eggs of the queen-bee that hatch males have not been fertilized; and, should she never have been impregnated and lay eggs, they will hatch only drones. In respect to the aphides (plant-lice), it is noticeable that, while their food is sufficient and of nutritious quality, their offspring is exclusively females, propagated parthenogenetically; but soon after the supply of food, owing to a change of season or circumstances, is diminished, young male aphides appear. Among the higher order of animals Prof. Hartshorne found an argument in the sex of double monsters. Stating that the birth of double monsters was due to fissure of the ovum and excess of formative power, he asserted that it is well known that in the majority of instances these monsters were of the female sex. He brought forward the vital statistics of different nations and their varying proportion of male and female births in support of his position, attributing the differences to increasing or diminishing vitality; and even the continually lessening reproductive powers of American women formed one of the illustrations of this theory.

SYMPATHETIC VIBRATIONS.

Prof. Joseph Lovering, of Cambridge, Mass., gave an interesting address on vibration, illustrated by an experiment. It was presumed that the members were more or less familiar with Milde's experiment with a tuning-fork and vibrating thread. This optical method of Milde is very much improved by using a large bar of iron and perpetuating the motion by means of magnetic excitement, the vibration being thus maintained for any length of time. A cord 20 or 30 feet in length is thus thrown into vibration. When the first suspension bridge was building in England, a fiddler offered to fiddle it away. Striking one note after another, he eventually hit its vibrating note, or fundamental tone, and threw it into such extraordinary vibrations that the bridge-builders had to beg him to desist. Only recently a bridge went down under the tread of infantry in France who had not broken step, and 300 were drowned. An experiment is often referred to of a tumbler or a small glass vessel being broken by the frequent repetition of some particular note by the human voice. It is said, and may be true, that certain German tavern-keepers increase their custom by the occasional performance of this feat. In the Talmud there is a curious question raised as to what would be the damages if a domestic vessel were broken by a noise made by an animal, such as a barking dog. Prof. Lovering here exhibited two pieces of clock-work, each giving a button a circular velocity of rotation. These are to turn a cord much as a skipping-rope is turned. The rotation twists an ordinary cord—or untwists it, as the case may be—and to avoid this twisting a tape is substituted, and a twisting or rotating machine is placed at each end. The chief difficulty now remaining is to have the machines twist in unison, which is difficult, as the two pieces of clock-work vary from each other, but on the whole the experiment is usually satisfactory. The tape was stretched across the stage, and the machines to rotate it were placed at each end. If the string is too slack for one segment of vibration, it subsides into parts, each having a vibration similar to the other. The tighter the string is drawn, the fewer the segments of harmonic vibration. The string started with five waves or segments of vibration. Drawn tighter, these were reduced to four, three, and finally two segments, the nodal point in each instance between the waves remaining perfectly unmoved. With a shorter string the first harmonic note was reached, and

ultimately the fundamental note or a single vibration was exhibited. Very high harmonies were shown by means of a very flexible string with a high velocity dividing the revolving tape into very numerous equal segments of vibration, or, as the professor preferred to call them, harmonics.

Petroleum in Santo Domingo.—In a note to the *Mechanics' Magazine*, Mr. William M. Gabb describes a petroleum-spring situated three miles north of the town of Azua, in Santo Domingo. It is near a stream, the name of which signifies "stinking water." The spring makes its appearance as a stagnant, torpid pool, exuding slowly through a heavy gravel-deposit. A very small area in the vicinity is covered with deposits of pitch, and, for half a mile down the dry bed of a rain-water stream, the gravel and sand are more or less cemented by an impure pitch, sometimes plastic, oftener hardened to asphaltum. The water is colored a dirty brown by the presence of the oil. Jets of gas bubble up at different points near the spring. The gas is not inflammable, and has more of a fetid than kerosene odor. In appearance and mode of occurrence the spring strikingly resembles those of Trinidad and California. It is the only spot on the island where bituminous products are found.

Photographing the Eye and Ear.—Dr. Vogel writes to the *Philadelphia Photographer* as follows: "That the interior of the human eye has been photographed is well known. The experiment is a somewhat cruel one for a living subject; still there are victims who stand it. I know, for instance, a very handsome young lady, whose brother is a physician, who patiently takes extract of belladonna until the pupil has become sufficiently enlarged; the interior of the eye is then illuminated with magnesium-light, and photographed. In a similar manner has the ear been photographed, that is to say, the tympanum only. A tube is inserted, in which is a mirror inclined at a certain angle. The mirror throws light into the interior of the ear. The mirror is also provided with a central hole through which the illuminated tympanum can be inspected. A system of lenses projects an image on the sensitive plate, and the picture is made in the ordinary manner."

Chemical Influence of Light.—In a recent lecture on the chemical action of light, Prof. Roscoe gives some interesting facts concerning the chemical effects of sunlight at different times of the day, and in different atmospheres. The number of chemically-active rays vary throughout the day. Their maximum is always highest at noon. The curve of the heating rays reaches its highest point after noon, but this is not the case with the chemically-active rays. The chemical intensity appears to depend solely on the height of the sun in the heavens, and at the same distance from noon; on either side it appears to be equal. The chemical power of sunlight also varies with the place. Prof. Roscoe gives the results of measurements at Kew, Lisbon, and Para. At Kew the intensity was 94.5, at Lisbon 110, and at Para 313. An opalescent atmosphere appears to cause the absorption of a large number of the chemically-active rays. Hence the important advantage, in point of vegetation, which those countries have where the atmosphere is clear.

The Leaf a Vicarious Organ.—Some interesting experiments have lately been conducted by M. Calliet, to determine the precise action of plant-leaves in the absorption of water in the liquid form. They have led him to the conclusion that leaves do not absorb water while the roots are supplied. But when the ground is too dry for the roots to obtain it, if water be put in contact with the leaves, they will absorb it for the nourishment of the plant. The experimenter thus educes the fact that the action of the leaf is a vicarious and not a natural function.

Carbolic Acid from Plants.—M. Broughton, government chemist, attached to the cinchona-plantations of Ootacamund, in India, has obtained carbolic acid from the *Andromeda Leschmantii*, a plant which grows there abundantly. The product is less deliquescent than that obtained from coal-tar, and, owing to the expense attending its preparation, is not likely to compete with the article at present in the market.

NOTES.

A COMMITTEE of astute reformers in England, charged with the duty of devising some means for repressing drunkenness and reforming drunkards, recommend that drunkenness, and even the first offence, be severely punished. For the first conviction, a month in jail; for the third, a year's imprisonment in a reformatory. Whether public or private, attended with a breach of the peace or not, the drunkenness is to be made a crime, and dealt with accordingly; not so much for the protection of society, but avowedly as a reformatory measure. If a man degrades himself by getting drunk, degrade him still more by sending him to jail; destroy his remaining self-respect, to the end that his respect for himself may be increased!

DONNE and others have shown that water without air will acquire a temperature far above 212° without boiling, and that it is then liable to burst into steam with explosive violence. It is thought that many disastrous steam-boiler explosions have arisen from this cause; and a firm in Nottingham, England, have adopted a process which is said to entirely remove the difficulty. They inject heated air at a temperature of 650° Fahr., near the bottom of the water-space, into the boilers, waste-heat being utilized for the purpose. The incrustation of the boilers is thus prevented, the water is constantly aërated, and an economy of 15 per cent. secured; which in England alone, if the process were generally applied, would result in an annual saving of 16,500,000 tons of coal.

THE Royal Astronomical Society are urging the English Government to erect an astronomical observatory in the highlands of India. A station in the region named, besides being of great service to science as affording an opportunity for observations within the tropics, would be of immediate utility, in observing the transit of Venus, as it is said that the egress of the planet could be better watched in these highlands than in any other part of the British dominions.

AN inquiry into the foundering of the Peruvian steamer Calderon, in the bay of Biscay, has disclosed the fact that the leak resulted from corrosion caused by mercury spilled from the gauge-cocks into the bilge, where, by lodging under the boilers, and becoming oxidized with strong hot brine from the boiler-leaks, it was converted into oxychloride of mercury. In the recent investigation into the loss of the Megara, it was stated in evidence that the washing about of a copper nail, in the bilge of the iron steamer Grappler, destroyed one of her plates, and caused a dangerous leak. Both metals, when exposed to the action of salt-water, become converted into oxychlorides, which corrode iron rapidly when in contact with it.

IF iron is withheld from animals, they sooner or later show signs of disease, which in man is attended with a peculiar greenish pallor of countenance, great weakness, and general disturbance of the functions. It has been observed that plants grown in a soil without iron are affected in a similar way—that is, they are less thrifty, lose color, and give other indications of disorder. It is therefore inferred that iron is quite as essential to the growth of plants as to the growth of animals.

AN important discovery, which it is expected will ultimately reduce the cost of steam-power 60 per cent., has recently been made and put into practical operation in Boston. The discovery consists of a process by which the great amount of heat that now escapes into the air in the waste or exhaust steam from engines, is utilized by conducting it through the tubes of a boiler filled with bisulphide of carbon—a fluid which boils at 110° Fahr., and at the temperature of exhaust-steam gives a pressure of sixty-five pounds to the inch in the boiler. The vapor formed in this boiler is used to drive an engine, instead of steam, and after being used is condensed by cooling, pumped into the boiler again, and used continuously without loss. A number of carefully-made experiments are said to prove beyond question that, by means of this process, the same fuel now required to produce 100 horse-power, with the best engines in use, will produce 250 horse-power, showing a gain of 150 per cent. in the amount of power obtained by the consumption of coal. This is a very important discovery, and, if further experiments shall bear out the claim which is now made for it, will be of immense advantage to the entire manufacturing interests of the country. —*American Manufacturer.*

THE coloring-matter of the blood-corpuscles is known as *hæmatosin*, and the red color of this substance is generally attributed to the presence of iron. This, however, appears to be a mistake, since Malder and Van Gondoever have been able to abstract the iron entirely, and yet the hæmatosin was as red as ever.

M. GAUDAIN states that a mixture of equal parts of cryolite and chloride of barium forms a flux superior to borax for soldering iron, or brazing copper, brass, or bronze. Cryolite is a mineral that occurs in great abundance in Greenland. It is a double fluoride of sodium and aluminium, and has been largely employed in the production of the metal aluminium.

At the recent scientific meeting in Dubuque, Miss Swain read a paper entitled "Why we differ, or the Law of Variety." In regard to the sexes, she took the ground of Luke Owen Pike, that differences are due to the different proportions of the same qualities, men and women differing not in elemental composition, but in excess or defect of common properties. She is said to be the first lady who has ever addressed this Association, but she is certainly not the first who has contributed to its proceedings. Mrs. Elisha Foote prepared a paper, the result of her experimental investigations on heat, which was read at the meeting in Albany in 1856.

It is stated by Jean that our ordinary soaps are so adulterated, under pretence of cheapness, that little of soap remains but the name. The chief adulterant is resin, which combines with the potash or soda in place of the 50 or 60 per cent. of fatty acid that should be present. These alkaline resinates impart to the soap the power of lathering copiously, and they even saponify in water containing gypsum. These good properties are, however, counterbalanced by serious disadvantages. If resinous soaps are used in fulling cloth, they produce blemishes. They also impart to worsted stuffs a peculiar greasy lustre, and wool scoured with these takes the mordants and dyes unequally.

Woodman reported at Dubuque on ancient mounds. He says that these and other old earthworks are far more abundant than is generally supposed. The city of Dubuque, he states, is full of them, although they have been extensively obliterated without being recognized. They are almost invariably fifteen paces apart from centre to centre, the smaller ones being from two to two and a half feet high, and about twenty feet in diameter, and are arranged in straight or slightly-curved lines. Some mounds contain skeletons, and were probably designed for tombs, while other and larger mounds are supposed to have been residences of the ancient inhabitants of the continent.

Dr. G. W. Hough has introduced a printing-chronograph into the Dudley Observatory, which has been in operation a year and a half. Observations have been made in that time on 10,000 stars, and the number of records taken and printed amount to 150,000. The chronograph is an instrument for noting precisely the astronomical time at which the observation of a heavenly body is made. The first chronograph was a Morse register. Dr. Hough has improved upon this, and says that he can do twice as much work as formerly in the laboratory, by the use of the invention.

A paper from Prof. E. W. Hilgard, State Geologist of Mississippi, was contributed on "Soil Analyses and their Utility." Prof. Mapes a few years ago made a great deal of noise about soil analysis, and was accused of "running it into the ground." Prof. Johnson, of Yale, showed that there was a good deal of humbug about so-called soil-analyses, and pointed out the exaggerated value that is commonly attributed to them. But Prof. Hilgard has such faith in them that he proposes to vary the usual routine in State geological surveys by introducing them, and he thus returns to the policy of Emmons in conducting the New York State Geological Survey.

A new process, which has received the name of Helio-Autographic Printing, has recently been brought out in Paris. It is said to enable the artist to make his own designs and drawings, to print from them on photographic paper, and reproduce the same upon lithographic stone, so as to obtain impressions of his own work in the minutest detail, without the aid of the engraver, or lithographic draughtsman.

According to Schmidt, an excellent remedy against caterpillars consists in a dilute solution (1 part in 500) of sulphide of potassium, the infested tree being sprinkled with this substance by means of a small hand-syringe. This method has been used on a large scale in France, and, it is said, without any injury to vegetation.

According to the *Medical Times and Gazette*, the cholera is gradually making its way westward, having but recently entered Prussia. The disease is of a mild type, however, and spreads slowly. In Berlin it first appeared in one of the most fashionable streets in the city, three cases occurring nearly at the same time, in one and the same house.

Prof. Peirce exhibited at the Dubuque meeting some interesting astronomical photographs and engravings prepared by Prof. Winlock, of Harvard College. It appears, by these charts, that Jupiter changes his color even on successive nights. The representations of sun-spots were said to be very instructive, showing their connection with the solar protuberances; the drawings of the latter indicate an unmistakable atmosphere at an altitude of 100,000 miles.

A red color has sometimes been observed in white lead, and has been formerly attributed to the presence of silver. German investigations have recently shown that this is incorrect, and that the red tinge is due to defects in manufacture.

INDEX.

	PAGE
Action of Dark Radiations	202
" of Sewage-Gas on Lead Pipes	251
Addresses, The Presidential	752
Agassiz's South American Observations	505
A Giant Planet	286
A Glass of Water	655
Alcoholic Hallucinations	638
Alcohol, The Physiological Position of	219
A Marked Man	249
American Plants, On the Derivation of	724
Anæsthetic, A New	373
"Ancient America," Baldwin, Notice of	244
A New Entozoon from Common Eel	758
Animal Movements, Nervous Control of. (Illustrated.)	344
Anthropology and Ethnology	490
Antiquity of Man. (Illustrated.)	289
A Phosphorus-Lamp	252
Arrow-heads in New Jersey	253
Artificial Production of Stupidity in Schools	129
As regards Spiders. (Illustrated.)	674
Astro-Meteorology	335
Atmosphere of the Sun	251
Atoms	245
August and November Meteors	388
Balance of Life in the Aquarium	434
Binary Stars	754
Body, Temperature of, in Health	247
"Botany for Beginners" (by Maxwell T. Masters), Notice of	370
Bowlders of the Long Island Drift	757
Brain-Injury, Curious Effects of a	635
Brain, The Unconscious Action of	544
Bread, Detection of Alum in	509
Caffeine, Physiological Action of	253
Calmucks, Characteristics of the. (Illustrated.)	419
Carbolic Acid from Plants	766
Carpenter, Dr. William B., Sketch of	745
Cave Explorations, Recent	378

PAGE
Centenarians, Physical Condition of 253
Chameleonization in Frogs and Reptiles 376
Chemical Influence of Light 766
Cholera, Origin of 381
Civilization as Accumulated Force 602
Clever Fishes 529
Coal as a Reservoir of Power 738
Coal-Gas, Purification of 503
Coal-Lands of the Rocky Mountains 632
Coal, Weather-Waste of 374
Coast Survey, The Work of the 763
Comets, What becomes of? 246
Concerning Atoms 245
Concerning Crookes 126
Condiments, Physiological Influence of 701
Consanguineous Marriages and Idiocy 250
Consciousness after Decapitation 252
Cooling and Ventilation of Railway Carriages 251
Copper in Organized Structures 253
Corals and Coral Architecture 257
"Corals and Coral Islands" (by J. D. Dana), Notice of 241
Corpulence 445
Cow's Milk, Fungi in 636
Culture of Wild Plants 376

Dana, James D. (with Portrait) 362
" " Honors to 253
Darwinism and Divinity 188
Detection of Alum in Bread 509
"Dictionary of English Etymology" (Wedgewood), Notice of 118
Difficulties of the Social Science—Objective Difficulties 641
Discovery of the Elements 474
Disease, Gull on the Nature of 122
" Propagation of 509
Disinfection and Disinfectants 55
Dyspepsia, the Causes of 75

Early Superstitions of Medicine 95
Earthquake Waves, Measurement of 586
Eastern Thibet 379
Eclipse of the Sun. (Illustrated.) 17
Education, Modern Studies in 496
" Place of Science in 624
Effects of Faulty Vision in Painting 174
Emotion, the Physiology of 274
English against the Classics 586
Evolution, Mr. Martineau on 313
Experiments on the Solar Spectrum 631
Exploring Expeditions, Northern 508

Facts in Relation to Rainfall 504

PAGE
"First Book of Botany" (by E. A. Youmans), Notice of 120
Fish as Food 247
Flying Reptiles of the Chalk Formation in Kansas 380
Food, Nutritive Salts of 405
"Forms of Water" (Tyndall), Notice of 245
Fossil Flowers and Insects 252
Four-legged Fish 636
Frogs and Reptiles, Chameleonization in 376
Fungi in Cow's Milk 636

Gastric Juice, Late Researches on the 371
"Geological Surveys of Ohio," Notice of Report on 630
Germany, Scientific Advance in 251
Germination, Cold in 254
Gray, Prof., Sketch of (with Portrait) 491
Gun-Cotton, Spontaneous Explosions of 376
Guns, Length of 372

Has our Climate changed? 665
"Healthy Houses," Eassie, Notice of 628
Herbert Spencer and Dr. Carpenter 754
Higher Education, Modern Literatures in 396
Hints on House-building 126
Hooker, Dr., and the Kew Gardens 762
"How Plants behave," Gray, Notice of 502
Human Nature, The Study of 327
Hydrogen Flame, Observations on the 377
Hydrophobia, Chloral Hydrate in 507

Imported Enemies 620
Impure Water, Tests of 250
Insects and Flowers 758
"Instinct" (by P. A. Chadbourne), Notice of 117
Intellect, Town and Country as Producers of 600
Iron and Civilization 339
Is there a Social Science? 159

Judges, Juries, and Insanity 440
Jute 761

Knowledge, Loose and Accurate 238

Labor, The Source of 40
Lagoon Islands, Elevation of, in the Pacific 506
Lead Pipes, Action of Sewage-Gas on 251
Length of Guns 372
Lessons from a Brick 633
Liebig's Extract of Meat 373
Life in the Aquarium 484
Lightning-Rods, The Office of 639
Long Island Conglomerate 632
Loose and Accurate Knowledge 238

PAGE
Lyell, Sir Charles (with Portrait)..... 231

Magnetic Variations..... 254
Man, Natural History of, The Antiquity of Man. (Illustrated.)..... 208
" " " The Unity of the Human Species..... 61
" " " Migrations of..... 299
Man as an Object of Scientific Study..... 366
Man, Quetelet on the Science of..... 45
Man as the Interpreter of Nature..... 684
Measurement of Earthquake-Waves..... 586
Meat, Liebig's Extract of..... 373
" Preservation of..... 637
Medicine, The Early Superstitions of..... 95
Mental Exertions governed by Law..... 762
Meteors of August and November..... 388
"Michael Faraday," Gladstone, Notice of..... 627
Modern Literatures in the Higher Education..... 396
Modern Studies in Education..... 496
Moral Contagion..... 618
Morse, Prof., The Work of..... 115
Motions of the Stars..... 541
Mount Seward, Ascent of..... 636
Musical Mice..... 823, 510

Natural History of Man..... 61, 208, 299
Nature of the Social Science..... 513
New Jersey, Arrow-heads in..... 253
Niagara, the Past and Future of..... 564
"Niagara" (by G. W. Holley), Notice of..... 756
Northern Exploring Expeditions..... 508
Nutritive Salts of Food..... 408
Notes..... 128, 254, 383, 511, 640, 767

Observations on the Hydrogen Flame..... 377
On the Derivation of American Plants..... 724
Origin of Cholera..... 381
Our Need of a Social Science..... 1
Oxygen, The Discoverer of..... 368

Painting, Effects of Faulty Vision in..... 174
Past and Future of Niagara..... 564
Permanent Photographs..... 250
Petroleum in Santo Domingo..... 766
Photographing the Eye and Ear..... 766
Physical Condition of Centenarians..... 253
" Science, the Study of..... 451
" Degeneracy, the Causes of..... 482
Physiological Action of Caffeine..... 253
" Influence of Condiments..... 701
"Physiology of Man" (by Prof. Austin Flint, Jr.), Notice of..... 756
Place of Science in Education..... 624

PAGE
Planets, Do they vary in Color?..... 374
Popular Geology..... 613
Power, Coal as a Reservoir of..... 738
Prehistoric Times. (Illustrated.)..... 101
Preservation of Meat..... 637
" of Wood..... 508
Propagation of Disease..... 509
Providence in Physical Affairs..... 638
Purpose and Plan of Our Enterprise..... 113

Quetelet on the Science of Man..... 45

Radiations, Action of Dark..... 202
Railway Carriages, Cooling and Ventilation of..... 251
Rainfall, Facts concerning..... 504
Rats, Anecdotes of..... 375
Recent Strikes..... 623
" Cave Explorations..... 378
Relations of Death-rate to Temperature..... 378
Rising of Circumpolar Land..... 510

Sanitary Reform in India..... 373
School Dietaries..... 590
" Life and Eyesight..... 760
Scientific Advance in Germany..... 251
" Associations..... 637
" Dabblers..... 594
Science and Immortality..... 26
" of Man..... 45
"Science Primers" (Chemistry, by Prof. Roscoe; Physics, by Balfour Stewart), Notice of..... 371
Scrutable Providences..... 217
Seychelles Islands, Notes on the..... 505
Sight and the Visual Organ..... 457
Singing Marmot..... 509
Sleep, Physiology of..... 411
Society, the Science of..... 116
Sociology, the Study of..... 1, 159, 513, 641
Solar Spectrum, Experiments on the..... 631
Southern Alaska..... 124
"Spectrum Analysis" (Schellen), Notice of..... 242
Spontaneous Explosion of Gun-Cotton..... 376
Spots on the Sun. (Illustrated.)..... 144
Stimpson, Dr. William, Death of..... 502
Stimulation, The Question of..... 239
Sun, Atmosphere of the..... 251
" Recent Eclipse of. (Illustrated.)..... 17
" the Spots on. (Illustrated.)..... 144
Sympathetic Vibrations..... 765

Temperature of the body in Health..... 247
" Relations of Death-rate to..... 378

PAGE
The Deepest Well 253
"Theory of Heat" (by J. C. Maxwell), Notice of 500
The Female the Better Half 764
"The Lens," Notice of 627
The Leaf a Vicarious Organ 766
"The To-morrow of Death" (by Louis Figuier), Notice of 118
Thibet, Eastern 379
Town and Country as Producers of Intellect 600
Training, Effects of 252
Tyndall, Prof. 751

Unconscious Action of the Brain 544
Unity of the Human Species 61

Vegetable and Animal Food, On the Digestibility of 308
Ventilation, and the Reasons for it 356
Vesuvius 227
" Late Eruption of 379
Visual Images in Darkness 734

Waste, A City's 761
Water, Impurities of 248
Weather-Waste of Coal 374
Were the Ancient Italians Cannibals? 632
Wild-Plants, Culture of 376
Woman and Political Power 82
Wood, Preservation of 508
Writing Machine, A New 374

Yeast 573
Yellowstone National Park 381

Zoology of the Galapagos 633

END OF VOL. I.